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A STUDY OF THE RELATIVE EFFECTIVENESS OF VARIED VISUAL ILLUSTRATIONS. FINAL REPORT.

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DESCRIPTORS- *VISUAL LEARNING, VISUAL STIMULI, ILLUSTRATIONS, SECONDARY EDUCATION, *BIOLOGY INSTRUCTION, *PICTORIAL STIMULI, *STIMULUS DEVICES, PHYSIOLOGY, *INSTRUCTIONAL AIDS, INSTRUCTIONAL MATERIALS, GRADE 9, GRADE 10, GRADE 11, GRADE 12,

THE RELATIVE EFFECTIVENESS OF EIGHT TYPES OF VISUAL ILLUSTRATION OF THE HUMAN HEART WAS TESTED IN NINTH THROUGH TWELFTH GRADE CLASSES. THE EIGHT TYPES--ABSTRACT LINE DRAWINGS, DETAILED SHADED DRAWINGS, PHOTOGRAPHS OF HEART MODELS, AND REALISTIC MODELS, EACH IN BLACK AND WHITE AND IN COLOR--AND A CONTROL PRESENTATION WITH NO ILLUSTRATIONS WERE ASSIGNED RANDOMLY TO ONE CLASS EACH PER GRADE LEVEL. EACH TREATMENT CONSISTED OF A TAPE RECORDED ORAL PRESENTATION ON THE HEART, AND 39 SLIDES WHICH WERE IDENTICAL IN SIZE AND FORMAT TO THE SLIDES IN EACH OTHER TREATMENT. EVALUATIVE DEVICES WERE A PHYSIOLOGY KNOWLEDGE PRETEST, AND FOUR CRITERION PRETESTS IN DRAWINGS, IDENTIFICATION, TERMINOLOGY, AND COMPREHENSION, WHICH WERE USED AS IMMEDIATE AND TWO-WEEK-DELAYED PRETESTS. DATA FOR THE CRITERION TESTS WERE SUBJECTED TO ANALYSIS OF COVARIANCE, AND MEANS WERE COMPARED BY DUNN'S C-PROCEDURE TO AVOID OBTAINING SPURIOUS SIGNIFICANT DIFFERENCES. IN THE IMMEDIATE POST-TESTS, THE ABSTRACT LINEAR REPRESENTATIONS WERE SUPERIOR TO MORE "REALISTIC" PRESENTATIONS, PROBABLY BECAUSE THEY ISOLATED MATERIAL TO BE LEARNED AND DID NOT PRESENT OTHER IRRELEVANT STIMULI. SIGNIFICANT DIFFERENCES EXISTED ON THE IMMEDIATE POST-TESTS, BUT ON THE DELAYED MEASUREMENT, DIFFERENTIAL EFFECTS OF THE NINE TREATMENTS DISAPPEARED FOR ALL TESTS FOR ALL FOUR GRADES, WITH ONE EXCEPTION. APPENDICES INCLUDE A BIBLIOGRAPHY, THE EVALUATION INSTRUMENTS, THE TEACHER SCRIPT, AND SAMPLE VISUAL ILLUSTRATIONS. (BB)

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Principal Investigator
Francis M. Dwyer, Jr.
September 1967

U. S. DEPARTMENT of
HEALTH, EDUCATION, AND WELFARE
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OFFICE OF EDUCATION

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I. INTRODUCTION

Background

Extensive research in the field of visual education has established, in fact, that visual aids when used to complement instruction improve student achievement. There has been, however, very little research that attempts to identify which and what types of physical characteristics contained within visual illustrations are most efficient and effective in facilitating student learning; nor has there been extensive research attempting to establish guidelines specifying which types of visual illustrations are most effective in promoting the learning of specific types of educational objectives.

In the past it has been the consensus of opinion that an increase in the number of cues, or greater realism in the existing cues, in visual illustrations increases the probability that learning will be facilitated. Following this assumption, many researchers, multiple channel communicationists, have proceeded to fill all transmission channels, especially the pictorial, with as much information as possible. However, there has been no systematic attempt to determine the relative effectiveness of various types of visual illustrations. Consequently, any assumption that the mere addition of stimulus units to learning situations will increase communication effectiveness seems to be at best a very tenuous one because it does not seem reasonable to expect that cues would be equally effective in eliciting similar responses in complementing oral instruction. At the present time, we do not know: (1) what kinds of visual illustrations are most effective in complementing oral instruction; (2) which of the many types of visual illustrations being used in classrooms throughout the country are most effective in promoting the learning of specific educational objectives; (3) whether there is only one visual continuum for predicting visual effectiveness or several, each being related to student achievement of specific types of educational objectives; and (4) whether color, inherent within the various types of visual illustrations, affects to a measurable degree their ability to promote student learning of different types of educational objectives.

Definition of Terms

Learning Continuum (Visual) A continuum depicting a sequence of illustrated presentations ranging from low to high in their predicted efficiency to facilitate learning.

Media Media, as defined by Ely (11:91), are carriers of information which may be presented by or through themselves in ways to stimulate learning, i.e., books, films, filmstrips, slides, visual illustrations, and video tapes.

Realism Realism refers to the amount of realistic detail possessed within the various types of visual illustrations.

Statement of the Problem

At the present time there is very little clear evidence for instructors (teachers) to use as guidelines in selecting and using visual illustrations in their classes. They have no way of knowing whether one type of visual illustration is transmitting certain types of information, i.e., are realistic photographs more effective in transmitting specific types of information than are simple line drawings depicting the same information? They have no way of knowing which of the many types of available illustrations--line drawings, half tone drawings, sketches, black and white pictures, color pictures, detailed drawings, photographs (both color and black and white) are most effective in achieving the particular objectives they are designed to convey. The instructors also have no evidence as to whether the same types of visual illustrations will be equally effective in facilitating student learning of all kinds of educational objectives, or whether they will be equally as effective for students in different grade levels and in different subject areas. These are a few of the questions considered in this study.

What appears to be needed is a programmatic approach to the problem of effectiveness in visual illustrations. This problem seems to be approachable in terms of quality-control research wherein wide varities of visual stimulation are treated under organized and controlled conditions in order to facilitate the evaluation of their potential effectiveness in producing the many kinds of desired learning responses. In short, we need to be moving toward the creation of those conditions of visual effectiveness which will maximize the probability that the desired kinds of learning will occur.

Specific Objectives

This study investigates the possible existence of a visual continuum representing learning effectiveness which differs from the realism continuum based on existing realism theories. Specifically, this study attempts:

a. to measure the relative effectiveness of eight different types of visual illustrations used to complement oral instruction:

1. abstract line representations (black & white)
2. abstract line representations (color)
3. detailed, shaded drawings (black & white)
4. detailed, shaded drawings (color)
5. heart model photographs (black & white)
6. heart model photographs (color)
7. realistic heart photographs (black & white)
8. realistic heart photographs (color);

b. to determine at what point further increases of realism in visual illustrations fail to produce significant differences in the achievement of the specific educational objectives;

c. to determine whether there is only one visual learning continuum which may be utilized in facilitating the learning of the four types of educational objectives measured at the four grade levels--ninth, tenth, eleventh, and twelfth;

d. to measure the amount of immediate and delayed retention resulting from the use of black and white and colored visual illustrations to complement oral instruction;

e. to determine whether color in visual illustrations is an important variable in promoting student learning of the four educational objectives as measured by the criterion tests;

f. to determine whether the realism continuum proposed by the realism theories is an appropriate and reliable predictor of visual effectiveness when varied types of visual illustrations are used to complement oral instruction.

Hypotheses

The purpose of this study was to test the following null hypotheses:

(H_1) There are no differences on the total criterion test in immediate retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

H_o: $\mu_{I} = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_{V} = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$

(H_2) There are no differences on the four individual criterion tests in immediate retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

H_o: $\mu_{I} = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_{V} = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$

(H_3) There are no differences on the four individual criterion tests in immediate retention among students receiving black and white illustrations and those receiving colored illustrations in complementing their oral instruction.

H_o: $\mu_{II} = \mu_{III}$; H_o: $\mu_{IV} = \mu_{V}$; H_o: $\mu_{VI} = \mu_{III}$; H_o: $\mu_{VIII} = \mu_{IX}$

(H_4) There are no differences on the total criterion test in delayed retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

H_o: $\mu_{I} = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_{V} = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$

(H_5) There are no differences on the four individual criterion tests in delayed retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

H_o: $\mu_{I} = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_{V} = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$

(H_6) There are no differences on the four individual criterion tests in delayed retention among students receiving black and white illustrations and those receiving colored illustrations in complementing their oral instruction.

H_o: $\mu_{II} = \mu_{III}$; H_o: $\mu_{IV} = \mu_{V}$; H_o: $\mu_{VI} = \mu_{VII}$; H_o: $\mu_{VIII} = \mu_{IX}$

(H_7) There are no significant differences in the relative effectiveness of the various types of visual illustrations used to complement oral instruction among the grade levels participating in the study--ninth, tenth, eleventh, and twelfth.

Significance of the Study

This study could serve as a basis for exploring a fundamental visual learning continuum. First, the investigation attempts to determine the relative effects on learning of eight types of pictorial illustrations:

1. abstract line representations (black & white)
2. abstract line representations (color)
3. detailed, shaded drawings (black & white)
4. detailed, shaded drawings (color)
5. heart model photographs (black & white)
6. heart model photographs (color)
7. realistic heart photographs (black & white)
8. realistic heart photographs (color).

The variations in the amount of realism used in constructing the illustrations should present some additional evidence upon which decisions can be based relating to the economy of time and cost involved in the production of visual illustrations for instructional purposes. Second, this study is an inquiry into the suitability of the future use of the realism continuum as a dependable experimental variable. Third, this study attempts to supply direct evidence relative to which illustration types are most effective in facilitating the learning of different educational objectives. Fourth, color versus black and white sequences are evaluated in terms of their ability to complement oral instruction and to promote student learning of the varied learning objectives as measured by the several criterion tests. Finally, it attempts to identify points on the continuum where further increases of realism in the visual illustrations fail to produce significant gains in achievement in the desired types of learning.

The importance of this information is emphasized by the increased use of visuals in the various teaching methods, i.e., instructional slides, transparencies, photographs, filmstrips, films, and sketches, which are becoming an integral part of many curricula. And with the increased use of educational television and video tape to expand and improve instructional presentations, the construction of one or several experimentally-tested visual learning continuums for general and specific educational objectives appears essential.

II. REVIEW OF RELATED LITERATURE AND RESEARCH

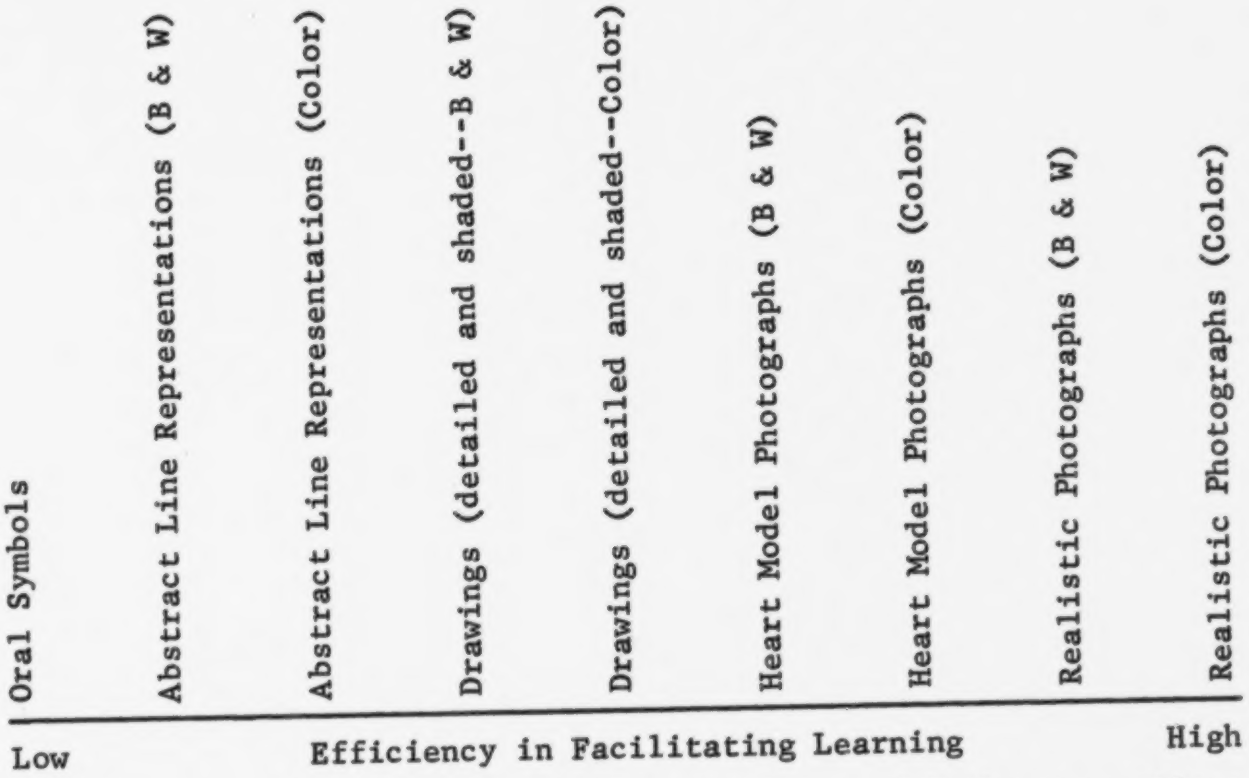
Introduction

Recent research and literature indicate that too much detail in an illustration tends to reduce learning via interference (Broadbent (3, 4), Attneave (2), Jacobson (19), Travers (32, 33)) and that detail in visual illustrations may be reduced to the point where its interpretation may cause unpredictable responses (Fleming (13)). Thus, the two ends of the continuum have been identified. The relative effectiveness of the visual illustrations falling in the middle area between the two identified points remains to be researched. Allen (1), Hoban (17), Schramm (29), and Dwyer (10) have stated that extensive research needs to be conducted on the physical characteristics inherent within pictorial illustrations which lead to increased learning and to the attainment of specific educational objectives.

Visual Realism Continuum

A visual realism continuum would extend from the object or situation itself to very simplified abstract line representations. The more qualities a visual has in harmony with the object or situation which it is to denote, the more realistic the visual is said to be. For example, in a continuum of illustrations, colored photographs would provide the most realistic impression of the object. However, the use of the abstract line representations would provide a more realistic presentation than would the oral description alone because the oral presentation provides no concrete form or orientation to the parts composing the object or situation.

By visualizing a realism continuum (Figure 1), one can see that realism is a matter of degree. The visual realism continuum is based on the contention that as the amounts of realistic detail in the visual illustration is increased, learning is also increased. A visual considered to be one hundred percent realistic with respect to a designated object could not be differentiated from the object because it would possess exactly the same qualities possessed by the original object. Oral instruction, therefore, would contain a low degree of realism, as it would not physically represent the denota. Consequently, it would follow that visual


Oral Symbols
Abstract Line Representations (B & W)
Abstract Line Representations (Color)
Drawings (detailed and shaded--B & W)
Drawings (detailed and shaded--Color)
Heart Model Photographs (B & W)
Heart Model Photographs (Color)
Realistic Photographs (B & W)
Realistic Photographs (Color)
Low
Efficiency in Facilitating Learning
High

Points on the Realism Continuum in accordance with the assumptions predicted by the "Realism Theories."

Figure 1. Realism Continuum for Still Visuals

illustrations, ranging from colored photographs to the black and white abstract line representations, may vary in their ability to achieve specific learning objectives. Research based upon the visual realism continuum was guided by the hypothesis that there does exist, in reality, a stimulus continuum which consists of a group of stimuli which can be arranged in ascending or descending order with respect to the presence of some discriminable quality or aspect--that quality being similarity to the denota. The assumption is: the higher the degree of similarity between the object or situation and the visual to which it refers, the easier it will be for the students to learn from it.

Realism Theories

The present study has evolved out of the inconsistencies resulting from the research guided by the "established" theoretical orientations, specifically the iconicity theory identified by Morris (26), the sign similarity orientation developed by Carpenter (6), and Dale's (7) cone of experience. For purposes of convenience the above orientations are referred to collectively as the realism theories. According to Finn (12), the basic concept around which audiovisual theories have been oriented is the concrete-to-abstract dimension of learning. The writings of several other authors appear to substantiate this basic concept presented by Finn, i.e., Gibson's (15) projective-conventional continuum, Osgood's (27) more detachable-less detachable continuum and Knowlton's (20) transparency-opacity continuum.

The basic assumption held by each of the proponents of the cited realism theories is that learning will be more complete as the number of cues in the learning situation increases. They suggest that an increase in realism in the existing cues in a learning situation increases the probability that learning will be facilitated, i.e., the more qualities a visual has in harmony with the object or situation to be depicted, the more realistic the visual; therefore, learning will be easier. (Figure 1)

Although it has been established that the use of carefully prepared visual aids can facilitate student achievement, there has been little attempt to determine the relative effectiveness of the various types of visual illustrations in promoting student learning of varied educational objectives. Miller, et al. (25: 18-85) have stated that it would be a mistake to assume that one cue added to another would increase learning by a linear increment.

Their contention is that additional cues or excessively realistic cues may be distracting or possibly even evoke competitive responses to the desired learning. Such cues would be labeled as interference and would reduce rather than facilitate learning. Accordingly, Bruner, et al. (5), and Travers, et al. (32) have suggested that learners do not need highly embellished stimuli in order to recognize the attributes of an object or situation which in turn would place it in a particular category facilitating identification. Travers, et al. (32:1.19) maintain that ". . . merely confronting a person with stimuli identical to those emitted by the real environment is no guarantee that useful information will be retained." Dale (8) has supported this contention. The available evidence (French (14), Miller (24), Rappaport (28), Travers (33), and Attneave (2)) seems to indicate that the effectiveness of discrimination learning promoted by the addition of relevant stimuli may be limited by the information processing capacity of the organism with learning reaching an early peak and then diminishing with the addition of relative, but superfluous, cues.

Broadbent (3, 4) has explained that the reduction of learning as the cue stimulation increases is caused by the filtering process in the central nervous system which prevents much of the realistic stimuli from receiving active reception in the brain. Jacobson (18, 19) has stated that the brain is capable of utilizing only minute proportions of the information perceived. Recent research, Livingstone (21, 22, 23), indicates that receptor sensitivity to stimuli may be reduced or inhibited by processes of the central nervous system.

Summary

The cited research and literature seem to indicate that merely presenting a student with stimuli identical to those emitted by the real environment is not necessarily the most effective way to facilitate learning. Since excesses of realism may actually interfere with the transmission of information and because of man's inability to receive highly embellished stimuli, it becomes necessary for those educators who are concerned with the structure of visual illustrations to attempt to discover those stimuli characteristics that insure that the subject will obtain the intended kinds of learning. It seems imperative that programmatic research be conducted along these lines since the related literature and research seem to indicate that reality may be edited for instructional purposes.

The literature also indicates that the reduction of the realism in a pictorial illustration does not necessarily reduce its instructional effectiveness and in many cases improves it, as long as the symbolic illustration contains the essence of the phenomena (Travers (33), Attneave (2), Dwyer (10)).

Research has also indicated that the realistic characteristics of an illustration may be reduced to the point where its interpretation may cause unpredictable responses (Fleming (13)).

III. PROCEDURES

Introduction

The purpose of this chapter is to give the reader additional information about the experimental population, the tests, the experimental procedures, the statistical design, and the instructional materials which were used in this study. As has been indicated, the basic purpose of this study was to compare the relative effectiveness of varied types of visual illustrations in complementing oral instruction on four criterion tests designed to measure student achievement on different educational tasks. Furthermore, it intends to investigate the possibility that the variations in learning effectiveness of the varied types of visual illustrations existed between pupils in various grade levels--specifically, the ninth, tenth, eleventh, and twelfth grades.

Administrative Arrangements

Before the experimental treatments could be presented to the students a number of administrative and logistical questions had to be resolved. Arrangements were made with the responsible personnel in the selected school systems to discuss the feasibility of conducting the study in their schools. Objectives of the study, availability of facilities, procedural requirements, types of equipment needed, and teacher involvement were some of the topics reviewed. After the feasibility of conducting the study was established, tentative dates were established and arrangements were made for the investigator to visit each school system and conduct an orientation session for the teachers who were to participate in the study. At these sessions, the objectives of the study were reviewed, the experimental procedures were discussed, and the intent of the physiology pretest, the immediate post-tests, and the delayed retention tests were examined. The teachers were given instruction leaflets which described in detail the experimental procedure to be followed during the instruction and evaluation phases of the study and also their particular role in the study. In addition, the availability of appropriate equipment was examined in detail. Where additional equipment was needed, arrangements were made to rent sets of equipment (tape recorder, slide projector, screen) from the Audio-Visual Services, The Pennsylvania State University.

Preparation of Materials

It was necessary to design and photograph nine complete 2" x 2" slide sequences for this study. Each sequence consisted of thirty-nine slides. Five sequences were in black and white and four were in color. All slides were taken on high speed Nicon F 35mm film using a Micro 35mm reflex camera.

The realistic photographic sequence (B & W) was the first slide sequence produced. Fresh swine hearts were selected for the original photographs since they closely approximated the size of the human heart. The swine hearts were placed in a cooler immediately after removal to promote coagulation of the blood and to prevent discoloration. A veterinary surgeon performed the cuttings on the hearts so that photographs depicting the desired concepts could be obtained.

When the realistic photographs were produced, a graphic artist reproduced these illustrations in various forms. The line representations and the detailed, shaded drawings (both B & W and color versions) were based on the realistic photographs. The black and white and color versions of the heart model photographs were included in the study because they represented the type of visual illustrations currently being included in modern textbooks and they possessed more realistic detail than the detailed, shaded drawing presentations.

The graphic artists and the photographers expended every effort to provide visuals of the highest quality for each slide sequence. Extreme care was required to make certain that the same format and size relationships that appeared in the original heart photographs were conveyed to the drawing and eventually to the slide sequences.

The slide sequence used with the control group did not contain visual illustrations of the heart, but did contain printed word symbols designating concepts referred to in the oral presentation. The printed symbols were employed to facilitate the correct spelling of the terminology used and to enable the students to differentiate between those parts of the heart with similar pronounciation or similar spelling. The same set of printed symbols was used for all nine slide sequences. The symbols were located in similar positions in each slide of each of the nine slide sequences which contributed to the standardization of the printed symbols throughout each of the nine slide sequences.

The printed symbols were prepared by the Instructional Graphics Unit of the University Division of Instructional Services, The Pennsylvania State University. The slides were prepared by the personnel of the Still Photography Services of the University Division of Instructional Services, The Pennsylvania State University.

Arrows were employed in the visual illustrations to focus the students' attention on the particular part being discussed during the oral presentation. For maximum discrimination, black arrows were used to depict the parts of the heart represented by the abstract line representations. White arrows were used with the detailed, shaded drawings and with the realistic and heart model photographs which possessed half tones; thus, the white arrows more clearly pointed out the particular part of the heart being discussed.

Experimental Population

The experimental population for this study was selected from the Farrell School System, Farrell, Pennsylvania, and the Sullivan County High School, Laporte, Pennsylvania. At each grade level, each of the nine classes were assigned at random to one of the treatment groups. (Tables 1, 2, 3, 4).

Table 1. Assignment of the Ninth Grade Students into the Nine Treatment Groups.

	Male	Female	Total
Oral Presentation: Group I	14	17	31
Abstract Line Presentation (B & W): Group II	17	15	32
Abstract Line Presentation (Color): Group III	16	16	32
Detailed, Shaded Drawing Presentation (B & W): Group IV	12	16	28
Detailed, Shaded Drawing Presentation (Color): Group V	14	13	27
Heart Model Presentation (B & W): Group VI	17	16	33
Heart Model Presentation (Color): Group VII	15	15	30
Realistic Photographic Presentation (B & W): Group VIII	16	17	33
Realistic Photographic Presentation (Color): Group IX	17	13	30
Total	138	138	276

Table 2. Assignment of the Tenth Grade Students into the Nine Treatment Groups.

	Male	Female	Total
Oral Presentation: Group I	18	13	31
Abstract Line Presentation (B & W): Group II	10	14	24
Abstract Line Presentation (Color): Group III	16	12	28
Detailed, Shaded Drawing Presentation (B & W): Group IV	13	12	25
Detailed, Shaded Drawing Presentation (Color): Group V	15	15	30
Heart Model Presentation (B & W): Group VI	16	9	25
Heart Model Presentation (Color): Group VII	8	22	30
Realistic Photographic Presentation (B & W): Group VIII	13	15	28
Realistic Photographic Presentation (Color): Group IX	20	11	31
Total	129	123	252

Table 3. Assignment of the Eleventh Grade Students into the Nine Treatment Groups.

	Male	Female	Total
Oral Presentation: Group I	17	14	31
Abstract Line Presentation (B & W): Group II	19	13	32
Abstract Line Presentation (Color): Group III	10	14	24
Detailed, Shaded Drawing Presentation (B & W): Group IV	20	12	32
Detailed, Shaded Drawing Presentation (Color): Group V	15	18	33
Heart Model Presentation (B & W): Group VI	11	19	30
Heart Model Presentation (Color): Group VII	13	9	22
Realistic Photographic Presentation (B & W): Group VIII	19	14	33
Realistic Photographic Presentation (Color): Group IX	15	12	27
Total	139	125	264

Table 4. Assignment of the Twelfth Grade Students into the Nine Treatment Groups.

	Male	Female	Total
Oral Presentation: Group I	4	16	20
Abstract Line Presentation (B & W): Group II	13	17	30
Abstract Line Presentation (Color): Group III	20	11	31
Detailed, Shaded Drawing Presentation (B & W): Group IV	17	20	37
Detailed, Shaded Drawing Presentation (Color): Group V	13	16	29
Heart Model Presentation (B & W): Group VI	22	14	36
Heart Model Presentation (Color): Group VII	23	8	31
Realistic Photographic Presentation (B & W): Group VIII	19	10	29
Realistic Photographic Presentation (Color): Group IX	7	12	19
Total	138	124	262

The eight visual groups were considered to be the treatment groups and the non-visual group the control group. Each subject participated in only one learning situation. Information transmitted to each student via the oral channel was held constant for each presentation and the amount of realism possessed by the visual illustrations was varied for each of the eight treatment groups.

Before the students received their respective presentations the purpose of the study was explained to them. They were informed that they would be tested immediately following the instruction period, and that they would receive five cents for each correct answer obtained above the mean achieved by their respective treatment group. The same award held true for the retention test, which was administered two weeks later. However, the students had not been informed in advance that they were to be retested.

Students receiving the pictorial presentations viewed their respective visuals for equal amounts of time. Students in the oral presentation viewed printed symbols representing the part of the heart being discussed during the time the students in the pictorial treatments viewed illustrations depicting the concepts being discussed. The rate and number of words per minute were identical for each presentation. The instruction period for each group was thirty-two minutes in length.

Treatment Groups

Oral Presentation: Group I

Students in Group I received oral symbols throughout the entire presentation from a tape recorder. Printed word symbols depicting the proper spelling of the parts of the heart were projected on the screen as they were mentioned in the oral presentation. There were no visual illustrations used in the oral presentation.

Abstract Line Presentation (B & W): Group II

Students in Group II received the same oral instruction as students in Group I. In addition, they received abstract line illustrations depicting the form and the relative locations of the parts of the heart as they were mentioned in the oral instruction. The line drawings used in this presentation were similar to instructional drawings used in many current science textbooks. The line drawings used in this presentation were black and white (black lines on a white field).

Abstract Line Presentation (Color): Group III

Students in Group III received the same oral instruction as students in Group 1. In addition, they received abstract line visual illustrations similar to those received by the students in Group II; however, these illustrations were in color. The line drawings used in this presentation were blue and pink (blue lines on a pink field).

Detailed, Shaded Drawing Presentation (B & W): Group IV

Students in Group IV received the same oral instruction as students in Group I. In addition, they viewed detailed, shaded drawings representing the parts of the heart as they were mentioned in the oral instruction. These drawings were more complex than the abstract line drawings and more realistically represented the heart and its related parts rather than merely identifying and locating them as in the former line representations.

Detailed, Shaded Drawing Presentation (Color): Group V

Students in Group V received the same oral instruction as students in Group I. In addition, they received visual illustrations similar to the illustrations received by the students in Group IV; however, these visuals were in realistic color.

Heart Model Presentation (B & W): Group VI

Students in Group VI received the same oral instruction as students in Group I. In addition, they viewed black and white photographs of a heart model as the heart and its related parts were being discussed orally.

Heart Model Presentation (Color): Group VII

Students in Group VII received the same oral instruction as students in Group I. In addition, they viewed colored photographs of a heart model as the heart and its related parts were being discussed orally.

Realistic Photographic Presentation (B & W): Group VIII

Students in Group VIII received the same oral instruction as students in Group I. In addition, they viewed realistic black and white photographs of the heart as the heart and its related parts were being described orally.

Realistic Photographic Presentation (Color): Group IX

Students in Group IX received the same oral instruction as students in Group I. In addition, they viewed realistic colored photographs of the heart similar to the black and white sequence received by students in Group VIII.

Test Administration

The physiology pretest was administered to all students prior to the time they received their respective instructional treatments.

On the day that the study was conducted, a teacher who had been thoroughly briefed and who was familiar with the experimental procedures to be followed was in attendance in each room to give directions, distribute materials, present the instructional unit, and answer procedural questions. Prior to the instructional presentation, the students were told the general nature of the study and that the study was concerned with the evaluation and improvement of visual illustrations as instructional aids. The investigator also gave each group of students a brief orientation to the study via audio tape. The oral instructional unit was presented to the students by means of a tape recorder. During the oral instruction the teacher changed the slides at the appropriate time to provide a complement to the oral presentation and depict visually the same information that was being presented orally. The synchronized presentation was produced by placing an audio impulse on the tape enabling the teacher to change the slides at the appropriate time. The teachers also had in their possession a copy of the heart script which presented verbally and visually which slide the students should be viewing when a particular portion of the oral instruction was being presented. The post-tests were administered immediately after the completion of the instructional presentation. When the individual completed work on one test, he handed it in and he received another until he had the opportunity to work on each of the four criterion tests--drawing test, identification test, terminology test, and comprehension test.

Procedures followed during the delayed retention tests, which were given two weeks later, were essentially the same as those for the immediate post-tests. However, the instructional presentation was not shown again. The teachers who were already familiar with the experimental procedures administered the delayed retention tests, i.e., the drawing test, the identification test, the terminology test, and the comprehension test.

Criterion Measures

Drawing Test

The drawing test (N=eighteen items) provided the student with a list of specific terms corresponding to the parts of the heart discussed in the verbal presentation. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. In this test emphasis was placed on the positioning of the verbal symbols with respect to their concrete referents, not the quality of the diagram they were to draw.

Identification Test

This multiple choice test (N=twenty items) required students to identify the numbered parts on a detailed drawing of a heart. Each part of the heart, which had been discussed in the oral presentation, was numbered on the drawing. The students were provided with an answer sheet with corresponding numbers on which they could select the name of the part of the heart which corresponded to the number.

Terminology Test

This test (N=twenty items) consisted of a series of fill-in questions; it was possible for one and only one specific answer to be correct. This test attempted to measure the learner's knowledge of referents for specific symbols or knowledge of the referent which would be most appropriately associated with the use of a specific symbol.

Comprehension Test

The comprehension test consisted of twenty multiple choice items. Direct reference was made to the position of specific parts of the heart while functioning. The student was then asked to identify the position that other specified parts of the heart would be occupying at that particular moment. This test required that the students have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes which occur during the systolic and diastolic phases. The comprehension test was designed to measure a type of understanding that occurs when the individual understands what is being communicated and when he can use the information being received to explain some other phenomena.

Total Criterion Test

Scores received on the four individual criterion tests were combined in a composite seventy-eight item criterion test designed to measure total understanding of the concepts presented.

Physiology Pretest

A physiology pretest consisting of thirty-six multiple choice items was administered to all participants in an attempt to determine their prior factual knowledge of the functional aspects of human physiology. Scores on this test were used as the adjusting variable in the analysis of covariance technique to evaluate the relative effectiveness of the various treatment groups receiving oral instruction complemented by visual illustrations.

IV. STATISTICAL ANALYSES AND RESULTS

A. Immediate Retention Analysis

Introduction

The data used in the statistical analysis (immediate retention) were secured from 1,054 subjects who composed the entire experimental sample. Information was secured from each participant prior to the instruction period, immediately following the instruction session, and two weeks later. Each subject received a pretest and four individual criterion tests, the latter being combined in a composite seventy-eight item test designed to measure total understanding of the concepts presented. Group achievement was evaluated in terms of total test score and in terms of scores achieved on the criterion tests.

An analysis of covariance was computed in order to test the hypotheses presented in Chapter I. The author used the programs "Analysis of Variance" and "Analysis of Covariance" which were prepared by the staff of the Computation Center at The Pennsylvania State University. These programs were designed to handle single classifications with unequal observations in subclasses. The IBM 7074 was used for part of the analyses. The Digitek Optical Reader 100 was used to score student responses to the pretest, the identification test, and the comprehension test.

The adjusting variable for the analysis of covariance was the physiology pretest scores; the dependent variables were criterion test scores on the four individual criterion tests and the total test score. An analysis of covariance was also used on the data obtained from the delayed retention test with the immediate total retention test scores being used as the adjusting variable. The Pearson _r_ between the immediate total retention test scores and the physiology pretest scores for the ninth, tenth, eleventh, and twelfth grades was .41, .46, .49, and .46 respectively. These correlations are significantly different from zero at the 0.01 level.

A method was sought which would allow the achievement of the several treatment groups, on the sub-tests and total test, to be tested for significance. The analysis of covariance and the corresponding test for significance based upon the F distribution permitted this to be done. The F distribution shows the variation to be expected in the ratio of the variances of independent samples drawn at random from the same population. If the F test shows there is a significant variance among a group containing more than two means, then a further test is needed to determine whether there is a significant difference between any one mean and any other mean. In testing for significance of differences among the means, Dunn's c-procedure ((9); Sparks (30)) was used to compare the means of the independent samples. The formula used was:

$$c = \frac{\overline{X}_i - \overline{X}_j}{\sqrt{ms_w \left(\frac{1}{n_i} + \frac{1}{n_j}\right)}}$$

Dunn's c-procedure was selected because many of the current texts and reference books used by educational researchers are quite sharp in their condemnation of the practice of performing t-tests on each pair of means as a method of testing the hypothesis that, in a completely randomized design, $M_1 = M_2 = \ldots M_i$ when $K > 2$ (Sparks (30), p. 343). Steel and Torrie (31) have indicated that in an investigation consisting of three different treatments, the observed value of "t" will exceed the 0.05 level of significance about 13 percent of the time. This will occur even if differences among the treatment groups are not real. This change in significance level is progressive; the greater the number of comparisons to be made, the greater the chances are of obtaining significant differences between the means, when, in fact, they do not exist. Dunn's c-procedure is based on the student's distribution. The power of this technique is in the fact that the investigator is required to limit the number of comparisons to be made between the means.

Comparison of the Ninth Grade Treatment Groups on the Total Criterion Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=5.69). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted in the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

H_o: $\overset{*}{\mu}_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (see Tables 5 and 6)

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*μ represents the mean score for the population.

Table 5. Analysis of Variance and Covariance of the Immediate Total Criterion Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	5202.60	650.33	5.20**	8	4656.36	582.04	5.69**
Within Groups	267	33529.51	125.11		266	27202.16	102.26	
Total	275	38732.11			274	31858.52		

**Significant at the 0.01 level.

Table 6. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Total Criterion Test.

Treatment	n	s.d.	Mean Physiology Test Scores Initial	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	31	5.98	14.35	25.19	26.29
Abstract Line Presentation (B & W; Group II)	32	14.89	15.16	39.41	39.61
Abstract Line Presentation (Color; Group III)	32	12.19	16.06	34.69	33.84
Detailed, Shaded Drawing Presentation (B & W; Group IV)	28	10.76	14.75	35.18	35.84
Detailed, Shaded Drawing Presentation (Color; Group V)	27	12.35	15.26	40.26	40.35
Heart Model Presentation (B & W; Group VI)	33	10.26	15.42	32.21	32.12
Heart Model Presentation (Color; Group VII)	30	8.37	15.77	36.68	36.20
Realistic Photographic Presentation (B & W; Group VIII)	33	9.87	15.06	30.50	30.81
Realistic Photographic Presentation (Color; Group IX)	30	13.49	16.20	36.70	35.75
Grand Mean			15.34	34.42	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 7 were obtained:

Table 7. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	5.23
$\mu I = \mu III$	Group I = Group III	2.98
$\mu I = \mu IV$	Group I < Group IV	3.62*
$\mu I = \mu V$	Group I = Group V	5.28
$\mu I = \mu VI$	Group I = Group VI	2.30
$\mu I = \mu VII$	Group I < Group VII	3.86**
$\mu I = \mu VIII$	Group I = Group VIII	1.77
$\mu I = \mu IX$	Group I < Group IX	3.65*
$\mu II = \mu III$	Group II = Group III	2.26
$\mu II = \mu IV$	Group II = Group IV	1.44
$\mu II = \mu V$	Group II = Group V	0.28
$\mu II = \mu VI$	Group II = Group VI	2.99
$\mu II = \mu VII$	Group II = Group VII	1.34
$\mu II = \mu VIII$	Group II > Group VIII	3.48*
$\mu II = \mu IX$	Group II = Group IX	1.50
$\mu III = \mu IV$	Group III = Group IV	0.75
$\mu III = \mu V$	Group III = Group V	2.44
$\mu III = \mu VI$	Group III = Group VI	0.71
$\mu III = \mu VII$	Group III = Group VII	0.91
$\mu III = \mu VIII$	Group III = Group VIII	1.22
$\mu III = \mu IX$	Group III = Group IX	0.72
$\mu IV = \mu V$	Group IV = Group V	1.65
$\mu IV = \mu VI$	Group IV = Group VI	1.43
$\mu IV = \mu VII$	Group IV = Group VII	0.14
$\mu IV = \mu VIII$	Group IV = Group VIII	1.92
$\mu IV = \mu IX$	Group IV = Group IX	0.03
$\mu V = \mu VI$	Group V = Group VI	3.14
$\mu V = \mu VII$	Group V = Group VII	1.56
$\mu V = \mu VIII$	Group V > Group VIII	3.61*
$\mu V = \mu IX$	Group V = Group IX	1.71
$\mu VI = \mu VII$	Group VI = Group VII	1.61
$\mu VI = \mu VIII$	Group VI = Group VIII	0.52
$\mu VI = \mu IX$	Group VI = Group IX	1.42
$\mu VII = \mu VIII$	Group VII = Group VIII	2.12
$\mu VII = \mu IX$	Group VII = Group IX	0.17
$\mu VIII = \mu IX$	Group VIII = Group IX	1.92

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of the space limit.

Comparison of the Ninth Grade Treatment Groups on the Drawing Test

When the nine treatment groups were compared on the basis of analysis of covariance on scores obtained on the Drawing Test, a F-value of 6.93, which is significant at the 0.01 percent level of confidence, was obtained. The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o{:}\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 8 and 9)

Table 8. Analysis of Variance and Covariance of the Drawing Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	1007.56	125.94	7.97**	8	1023.25	127.91	6.93**
Within Groups	267	4234.63	15.80		266	4906.34	18.45	
Total	275	5242.19			274	5929.59		

**Significant at the 0.01 level.

Table 9. Standard Deviaions and Adjusted Mean Scores for Each Treatment Group on the Drawing Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	1.80	3.64	3.97
Abstract Line (B & W; Group II)	4.76	10.19	10.25
Abstract Line (Color; Group III)	4.62	8.75	8.51
Detailed, Shaded Drawing (B & W; Group IV)	4.13	8.61	8.80
Detailed, Shaded Drawing (Color; Group V)	4.15	9.70	9.73
Heart Model (B & W; Group VI)	3.94	6.36	6.34
Heart Model (Color; Group VII)	3.31	10.35	10.21
Realistic Photographic (B & W; Group VIII)	3.78	7.50	7.59
Realistic Photographic (Color; Group IX)	4.45	7.83	7.55
Grand Mean		8.07	

When comparisons between the means of each treatment were considered in terms of Dunn's c-procedure, the values shown in Table 10 were obtained:

Table 10. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	5.80**
$\mu I = \mu III$	Group I < Group III	4.19**
$\mu I = \mu IV$	Group I < Group IV	4.31**
$\mu I = \mu V$	Group I < Group V	5.09**
$\mu I = \mu VI$	Group I = Group VI	2.21
$\mu I = \mu VII$	Group I < Group VII	5.72**
$\mu I = \mu VIII$	Group I = Group VIII	3.34
$\mu I = \mu IX$	Group I = Group IX	3.25
$\mu II = \mu III$	Group II = Group III	1.62
$\mu II = \mu IV$	Group II = Group IV	1.30
$\mu II = \mu V$	Group II = Group V	0.46
$\mu II = \mu VI$	Group II = Group VI	3.67*
$\mu II = \mu VII$	Group II = Group VII	0.04
$\mu II = \mu VIII$	Group II = Group VIII	2.48
$\mu II = \mu IX$	Group II = Group IX	2.47
$\mu III = \mu IV$	Group III = Group IV	0.26
$\mu III = \mu V$	Group III = Group V	1.09
$\mu III = \mu VI$	Group III = Group VI	2.04
$\mu III = \mu VII$	Group III = Group VII	1.57
$\mu III = \mu VIII$	Group III = Group VIII	0.86
$\mu III = \mu IX$	Group III = Group IX	0.88
$\mu IV = \mu V$	Group IV = Group V	0.80
$\mu IV = \mu VI$	Group IV = Group VI	2.23
$\mu IV = \mu VII$	Group IV = Group VII	1.26
$\mu IV = \mu VIII$	Group IV = Group VIII	1.09
$\mu IV = \mu IX$	Group IV = Group IX	1.11
$\mu V = \mu VI$	Group V = Group VI	3.04
$\mu V = \mu VII$	Group V = Group VII	0.42
$\mu V = \mu VIII$	Group V = Group VIII	1.91
$\mu V = \mu IX$	Group V = Group IX	1.91
$\mu VI = \mu VII$	Group VI < Group VII	3.60*
$\mu VI = \mu VIII$	Group VI = Group VIII	1.17
$\mu VI = \mu IX$	Group VI = Group IX	1.12
$\mu VII = \mu VIII$	Group VII = Group VIII	2.42
$\mu VII = \mu IX$	Group VII = Group IX	2.42
$\mu VIII = \mu IX$	Group VIII = Group IX	0.04

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted beacuse of the space limit.

Comparison of the Ninth Grade Treatment Groups on the Identification Test

When the nine treatment groups were compared on the basis of analysis of covariance on scores obtained on the Identification Test, an F-value of 2.67, which is significant at the 0.01 level of confidence, was obtained. The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general hull hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 11 and 12)

Table 11. Analysis of Variance and Covariance of the Identification Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	342.36	42.80	2.61**	8	318.51	39.81	2.67**
Within Groups	267	4398.02	16.41		266	3961.83	14.89	
Total	275	4740.38			274	4280.34		

**Significant at the 0.01 level.

Table 12. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Identification Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.54	6.48	6.75
Abstract Line (B & W; Group II)	4.69	9.81	9.86
Abstract Line (Color; Group III)	4.49	8.78	8.52
Detailed, Shaded Drawing (B & W; Group IV)	3.96	8.57	8.73
Detailed, Shaded Drawing (Color; Group V)	4.63	10.11	10.13
Heart Model (B & W; Group VI)	3.21	8.09	8.07
Heart Model (Color; Group VII)	3.93	9.10	8.98
Realistic Photographic (B & W; Group VIII)	3.44	7.09	7.17
Realistic Photographic (Color; Group IX)	5.05	9.63	9.40
Grand Mean		8.59	

When comparisons between the means of each treatment were considered in terms of Dunn's c-procedure, the values shown in Table 13 were obtained:

Table 13. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
μI = μII	Group I = Group II	3.20
μI = μIII	Group I = Group III	1.82
μI = μIV	Group I = Group IV	1.97
μl = μV	Group I = Group V	3.33
μl = μVI	Group I = Group VI	1.37
μl = μVII	Group I = Group VII	2.28
μI = μVIII	Group I = Group VIII	0.43
μl = μIX	Group I = Group IX	2.68
μII = μIII	Group II = Group III	1.39
μII = μIV	Group II = Group IV	1.13
μII = μV	Group II = Group V	0.27
μII = μVI	Group II = Group VI	1.87
μII = μVII	Group II = Group VII	0.90
μII = μVIII	Group II = Group VIII	2.79
μII = μIX	Group II = Group IX	0.47
μIII = μIV	Group III = Group IV	0.21
μIII = μV	Group III = Group V	1.60
μIII = μVI	Group III = Group VI	0.47
μIII = μVII	Group III = Group VII	0.48
μIII = μVIII	Group III = Group VIII	1.40
μIII = μIX	Group III = Group IX	0.90
μIV = μV	Group IV = Group V	1.35
μIV = μVI	Group IV = Group VI	0.67
μIV = μVII	Group IV = Group VII	0.25
μIV = μVIII	Group IV = Group VIII	1.56
μIV = μIX	Group IV = Group IX	0.66
μV = μVI	Group V = Group VI	2.06
μV = μVII	Group V = Group VII	1.13
μV = μVIII	Group V = Group VIII	2.94
μV = μIX	Group V = Group IX	0.71
μVI = μVII	Group VI = Group VII	0.94
μVI = μVIII	Group VI = Group VIII	0.93
μVI = μIX	Group VI = Group IX	1.37
μVII = μVIII	Group VII = Group VIII	1.86
μVII = μIX	Group VII = Group IX	0.42
μVIII = μIX	Group VIII = Group IX	2.27

The Roman numerals are not subscripted because of the space limit.

Comparison of the Ninth Grade Treatment Groups on the Terminology Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=4.48). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 14 and 15)

Table 14. Analysis of Variance and Covariance of the Terminology Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	343.87	42.98	3.78**	8	342.28	42.78	4.48**
Within Groups	267	3043.67	11.36		266	2536.82	9.54	
Total	275	3387.53			274	2879.10		

**Significant at the 0.01 level.

Table 15. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Terminology Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.77	5.42	5.73
Abstract Line (B & W; Group II)	4.12	7.75	7.81
Abstract Line (Color; Group III)	3.07	6.56	6.34
Detailed, Shaded Drawing (B & W; Group IV)	3.45	8.50	8.69
Detailed, Shaded Drawing (Color; Group V)	3.93	9.07	9.10
Heart Model (B & W; Group VI)	3.08	6.97	6.94
Heart Model (Color; Group VII)	3.14	7.35	7.22
Realistic Photographic (B & W; Group VIII)	3.14	5.56	5.65
Realistic Photographic (Color; Group IX)	3.51	7.70	7.43
Grand Mean		7.16	

When comparisons between the means of each treatment were considered in terms of Dunn's c-procedure, the values shown in Table 16 were obtained:

Table 16. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
μI = μII	Group I = Group II	2.67
μI = μIII	Group I = Group III	0.78
μI = μIV	Group I < Group IV	3.68*
μI = μV	Group I < Group V	4.14**
μI = μVI	Group I = Group VI	1.57
μI = μVII	Group I = Group VII	1.90
μI = μVIII	Group I = Group VIII	0.10
μI = μIX	Group I = Group IX	2.15
μII = μIII	Group II = Group III	1.90
μII = μIV	Group II = Group IV	1.10
μII = μV	Group II = Group V	1.60
μII = μVI	Group II = Group VI	1.14
μII = μVII	Group II = Group VII	0.76
μII = μVIII	Group II = Group VIII	2.80
μII = μIX	Group II = Group IX	0.48
μIII = μIV	Group III = Group IV	2.94
μIII = μV	Group III < Group V	3.42*
μIII = μVI	Group III = Group VI	0.78
μIII = μVII	Group III = Group VII	1.13
μIII = μVIII	Group III = Group VIII	0.89
μIII = μIX	Group III = Group IX	1.39
μIV = μV	Group IV = Group V	0.49
μIV = μVI	Group IV = Group VI	2.21
μIV = μVII	Group IV = Group VII	1.83
μIV = μVIII	Group IV > Group VIII	3.80*
μIV = μIX	Group IV = Group IX	1.55
μV = μVI	Group V = Group VI	2.69
μV = μVII	Group V = Group VII	2.31
μV = μVIII	Group V > Group VIII	4.27**
μV = μIX	Group V = Group IX	2.04
μVI = μVII	Group VI = Group VII	0.36
μVI = μVIII	Group VI = Group VIII	1.68
μVI = μIX	Group VI = Group IX	0.63
μVII = μVIII	Group VII = Group VIII	2.02
μVII = μIX	Group VII = Group IX	0.27
μVIII = μIX	Group VIII = Group IX	2.27

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of the space limit.

Comparison of the Ninth Grade Treatment Groups on the Comprehension Test

When the nine groups were compared on the basis of analysis of covariance on scores obtained on the Comprehension Test, an F-value of 2.12, which is significant at the 0.05 level of confidence, was obtained. The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradicted the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 17 and 18)

Table 17. Analysis of Variance and Covariance of the Comprehension Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	181.17	22.65	2.48*	8	145.32	18.17	2.12*
Within Groups	267	2450.30	9.14		266	2276.80	8.56	
Total	275	2631.47			274	2422.12		

*Significant at the 0.05 level.

Table 18. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Comprehension Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	4.10	9.64	9.83
Abstract Line (B & W; Group II)	3.55	11.81	11.85
Abstract Line (Color; Group III)	3.35	10.97	10.83
Detailed, Shaded Drawing (B & W; Group IV)	2.66	9.43	9.54
Detailed, Shaded Drawing (Color; Group V)	2.60	11.37	11.37
Heart Model (B & W; Group VI)	2.84	10.79	10.77
Heart Model (Color; Group VII)	2.23	11.00	10.92
Realistic Photographic (B & W; Group VIII)	2.54	10.41	10.46
Realistic Photographic (Color; Group IX)	2.81	11.87	11.70
Grand Mean		10.81	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 19 were obtained:

Table 19. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
μI = μII	Group I = Group II	2.74
μI = μIII	Group I = Group III	1.36
μI = μIV	Group I = Group IV	0.38
μI = μV	Group I = Group V	2.00
μI = μVI	Group I = Group VI	1.28
μI = μVII	Group I = Group VII	1.47
μI = μVIII	Group I = Group VIII	0.85
μI = μIX	Group I = Group IX	2.50
μII = μIII	Group II = Group III	1.39
μII = μIV	Group II = Group IV	3.05
μII = μV	Group II = Group V	0.63
μII = μVI	Group II = Group VI	1.49
μII = μVII	Group II = Group VII	1.26
μII = μVIII	Group II = Group VIII	1.90
μII = μIX	Group II = Group IX	0.20
μIII = μIV	Group III = Group IV	1.70
μIII = μV	Group III = Group V	0.71
μIII = μVI	Group III = Group VI	0.08
μIII = μVII	Group III = Group VII	0.12
μIII = μVIII	Group III = Group VIII	0.51
μIII = μIX	Group III = Group IX	1.17
μIV = μV	Group IV = Group V	2.32
μIV = μVI	Group IV = Group VI	1.64
μIV = μVII	Group IV = Group VII	1.81
μIV = μVIII	Group IV = Group VIII	1.22
μIV = μIX	Group IV = Group IX	2.81
μV = μVI	Group V = Group VI	0.79
μV = μVII	Group V = Group VII	0.58
μV = μVIII	Group V = Group VIII	1.19
μV = μIX	Group V = Group IX	0.43
μVI = μVII	Group VI = Group VII	0.20
μVI = μVIII	Group VI = Group VIII	0.43
μVI = μIX	Group VI = Group IX	1.26
μVII = μVIII	Group VII = Group VIII	0.62
μVII = μIX	Group VII = Group IX	1.04
μVIII = μIX	Group VIII = Group IX	1.67

The Roman numerals are not subscripted because of the space limit.

Comparison of the Tenth Grade Treatment Groups on the Total Criterion Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=11.23). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 20 and 21)

Table 20. Analysis of Variance and Covariance of the Immediate Total Criterion Test Scores for the Nine Treatment Groups.

Variance	Original Analysis D.F.	Original Analysis Sum of Squares	Original Analysis Mean Square	Original Analysis F	Adjusted Analysis D.F.	Adjusted Analysis Sum of Squares	Adjusted Analysis Mean Square	Adjusted Analysis F
Among Groups	8	10741.82	1342.73	10.06**	8	9819.14	1227.39	11.23**
Within Groups	243	32438.99	133.40		242	24284.08	100.35	
Total	251	43180.81			250	34103.22		

**Significant at the 0.01 level.

Table 21. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Total Criterion Test.

Treatment	n	s.d.	Mean Physiology Test Scores Initial	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	31	8.35	15.61	27.77	28.81
Abstract Line Presentation (B & W; Group II)	24	10.53	17.38	47.00	45.53
Abstract Line Presentation (Color; Group III)	28	16.39	16.68	42.00	42.16
Detailed, Shaded Drawing Presentation (B & W; Group IV)	25	13.17	20.24	40.68	35.14
Detailed, Shaded Drawing Presentation (Color; Group V)	30	12.06	14.93	45.90	47.90
Heart Model Presentation (B & W; Group VI)	25	7.13	16.56	31.36	31.05
Heart Model Presentation (Color; Group VII)	30	10.71	15.50	32.77	33.96
Realistic Photographic Presentation (B & W; Group VIII)	28	12.59	15.04	34.00	35.86
Realistic Photographic Presentation (Color; Group IX)	31	10.54	16.00	32.94	33.42
Grand Mean			16.34	36.97	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 22 were obtained:

Table 22. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	6.14**
$\mu I = \mu III$	Group I < Group III	5.11**
$\mu I = \mu IV$	Group I = Group IV	2.35
$\mu I = \mu V$	Group I < Group V	7.44**
$\mu I = \mu VI$	Group I = Group VI	0.83
$\mu I = \mu VII$	Group I = Group VII	2.01
$\mu I = \mu VIII$	Group I = Group VIII	2.70
$\mu I = \mu IX$	Group I = Group IX	1.81
$\mu II = \mu III$	Group II = Group III	1.21
$\mu II = \mu IV$	Group II > Group IV	3.63*
$\mu II = \mu V$	Group II = Group V	0.86
$\mu II = \mu VI$	Group II > Group VI	5.06**
$\mu II = \mu VII$	Group II > Group VII	4.22**
$\mu II = \mu VIII$	Group II > Group VIII	3.47*
$\mu II = \mu IX$	Group II > Group IX	4.45**
$\mu III = \mu IV$	Group III = Group IV	2.55
$\mu III = \mu V$	Group III = Group V	2.18
$\mu III = \mu VI$	Group III > Group VI	4.03**
$\mu III = \mu VII$	Group III = Group VII	3.12
$\mu III = \mu VIII$	Group III = Group VIII	2.35
$\mu III = \mu IX$	Group III = Group IX	3.35
$\mu IV = \mu V$	Group IV < Group V	4.70**
$\mu IV = \mu VI$	Group IV = Group VI	1.44
$\mu IV = \mu VII$	Group IV = Group VII	0.43
$\mu IV = \mu VIII$	Group IV = Group VIII	0.26
$\mu IV = \mu IX$	Group IV = Group IX	0.64
$\mu V = \mu VI$	Group V > Group VI	6.21**
$\mu V = \mu VII$	Group V > Group VII	5.39**
$\mu V = \mu VIII$	Group V > Group VIII	4.57**
$\mu V = \mu IX$	Group V > Group IX	5.64**
$\mu VI = \mu VII$	Group VI = Group VII	1.07
$\mu VI = \mu VIII$	Group VI = Group VIII	1.75
$\mu VI = \mu IX$	Group VI = Group IX	0.88
$\mu VII = \mu VIII$	Group VII = Group VIII	0.72
$\mu VII = \mu IX$	Group VII = Group IX	0.21
$\mu VIII = \mu IX$	Group VIII = Group IX	0.93

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Tenth Grade Treatment Groups on the Drawing Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=12.75). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 23 and 24)

Table 23. Analysis of Variance and Covariance of the Drawing Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	1664.32	208.04	11.71**	8	1577.42	197.18	12.75**
Within Groups	243	4315.90	17.76		242	3743.46	15.47	
Total	251	5980.22			250	5320.88		

**Significant at the 0.01 level.

Table 24. Standard Deviations and Adjusted Mean Scores for Each Treatment Group in the Drawing Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.70	5.16	5.44
Abstract Line (B & W; Group II)	3.60	14.83	14.44
Abstract Line (Color; Group III)	5.04	10.43	10.30
Detailed, Shaded Drawing (B & W; Group IV)	3.92	9.92	8.45
Detailed, Shaded Drawing (Color; Group V)	4.50	12.10	12.63
Heart Model (B & W; Group VI)	2.72	8.28	8.20
Heart Model (Color; Group VII)	3.55	9.07	9.38
Realistic Photographic (B & W; Group VIII)	5.47	8.79	9.28
Realistic Photographic (Color; Group IX)	4.54	7.61	7.74
Grand Mean		9.44	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 25 were obtained:

Table 25. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	8.42**
$\mu I = \mu III$	Group I < Group III	4.74**
$\mu I = \mu IV$	Group I = Group IV	2.85
$\mu I = \mu V$	Group I < Group V	7.14**
$\mu I = \mu VI$	Group I = Group VI	2.61
$\mu I = \mu VII$	Group I < Group VII	3.91**
$\mu I = \mu VIII$	Group I < Group VIII	3.74*
$\mu I = \mu IX$	Group I = Group IX	2.30
$\mu II = \mu III$	Group II > Group III	3.78*
$\mu II = \mu IV$	Group II > Group IV	5.33**
$\mu II = \mu V$	Group II = Group V	1.68
$\mu II = \mu VI$	Group II > Group VI	5.55**
$\mu II = \mu VII$	Group II > Group VII	4.70**
$\mu II = \mu VIII$	Group II > Group VIII	4.72**
$\mu II = \mu IX$	Group II > Group IX	6.27**
$\mu III = \mu IV$	Group III = Group IV	1.71
$\mu III = \mu V$	Group III = Group V	2.25
$\mu III = \mu VI$	Group III = Group VI	1.94
$\mu III = \mu VII$	Group III = Group VII	0.89
$\mu III = \mu VIII$	Group III = Group VIII	0.97
$\mu III = \mu IX$	Group III = Group IX	2.50
$\mu IV = \mu V$	Group IV < Group V	3.92*
$\mu IV = \mu VI$	Group IV = Group VI	0.22
$\mu IV = \mu VII$	Group IV = Group VII	0.87
$\mu IV = \mu VIII$	Group IV = Group VIII	0.77
$\mu IV = \mu IX$	Group IV = Group IX	0.67
$\mu V = \mu VI$	Group V > Group VI	4.16**
$\mu V = \mu VII$	Group V = Group VII	3.20
$\mu V = \mu VIII$	Group V = Group VIII	3.24
$\mu V = \mu IX$	Group V > Group IX	4.85**
$\mu VI = \mu VII$	Group VI = Group VII	1.11
$\mu VI = \mu VIII$	Group VI = Group VIII	1.00
$\mu VI = \mu IX$	Group VI = Group IX	0.44
$\mu VII = \mu VIII$	Group VII = Group VIII	0.10
$\mu VII = \mu IX$	Group VII = Group IX	1.63
$\mu VIII = \mu IX$	Group VIII = Group IX	1.50

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Tenth Grade Treatment Groups on the Identification Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=5.50). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 26 and 27)

Table 26. Analysis of Variance and Covariance of the Identification Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	712.19	89.02	5.52**	8	585.90	73.24	5.50**
Within Groups	243	3916.81	16.12		242	3223.82	13.32	
Total	251	4629.00			250	3809.72		

**Significant at the 0.01 level.

Table 27. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Identification Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.62	6.71	7.01
Abstract Line (B & W; Group II)	4.26	12.08	11.65
Abstract Line (Color; Group III)	5.11	10.07	9.93
Detailed, Shaded Drawing (B & W; Group IV)	4.24	11.68	10.06
Detailed, Shaded Drawing (Color; Group V)	3.85	11.90	12.48
Heart Model (B & W; Group VI)	3.82	9.48	9.39
Heart Model (Color; Group VII)	3.33	9.87	10.22
Realistic Photographic (B & W; Group VIII)	5.12	8.82	9.36
Realistic Photographic (Color; Group IX)	3.40	8.68	8.82
Grand Mean		9.83	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 28 were obtained:

Table 28. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	4.68**
$\mu I = \mu III$	Group I = Group III	3.07
$\mu I = \mu IV$	Group I = Group IV	3.11
$\mu I = \mu V$	Group I < Group V	5.85**
$\mu I = \mu VI$	Group I = Group VI	2.43
$\mu I = \mu VII$	Group I < Group VII	3.43*
$\mu I = \mu VIII$	Group I = Group VIII	2.47
$\mu I = \mu IX$	Group I = Group IX	1.95
$\mu II = \mu III$	Group II = Group III	1.69
$\mu II = \mu IV$	Group II = Group IV	1.52
$\mu II = \mu V$	Group II = Group V	0.83
$\mu II = \mu VI$	Group II = Group VI	2.17
$\mu II = \mu VII$	Group II = Group VII	1.43
$\mu II = \mu VIII$	Group II = Group VIII	2.26
$\mu II = \mu IX$	Group II = Group IX	2.85
$\mu III = \mu IV$	Group III = Group IV	0.13
$\mu III = \mu V$	Group III = Group V	2.66
$\mu III = \mu VI$	Group III = Group VI	0.54
$\mu III = \mu VII$	Group III = Group VII	0.30
$\mu III = \mu VIII$	Group III = Group VIII	0.58
$\mu III = \mu IX$	Group III = Group IX	1.17
$\mu IV = \mu V$	Group IV = Group V	2.45
$\mu IV = \mu VI$	Group IV = Group VI	0.65
$\mu IV = \mu VII$	Group IV = Group VII	0.16
$\mu IV = \mu VIII$	Group IV = Group VIII	0.70
$\mu IV = \mu IX$	Group IV = Group IX	1.26
$\mu V = \mu VI$	Group V = Group VI	3.13
$\mu V = \mu VII$	Group V = Group VII	2.40
$\mu V = \mu VIII$	Group V = Group VIII	3.25
$\mu V = \mu IX$	Group V > Group IX	3.92**
$\mu VI = \mu VII$	Group VI = Group VII	0.84
$\mu VI = \mu VIII$	Group VI = Group VIII	0.03
$\mu VI = \mu IX$	Group VI = Group IX	0.58
$\mu VII = \mu VIII$	Group VII = Group VIII	0.90
$\mu VII = \mu IX$	Group VII = Group IX	1.50
$\mu VIII = \mu IX$	Group VIII = Group IX	0.57

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Tenth Grade Treatment Groups on the Terminology Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=7.00). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contracted the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 29 and 30)

Table 29. Analysis of Variance and Covariance of the Terminology Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	657.26	82.16	7.41**	8	504.71	63.09	7.00**
Within Groups	243	2695.68	11.09		242	2180.62	9.01	
Total	251	3352.94			250	2685.33		

**Significant at the 0.01 level.

Table 30. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Terminology Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.04	5.90	6.16
Abstract Line (B & W; Group II)	3.25	8.17	7.80
Abstract Line (Color; Group III)	5.15	9.50	9.38
Detailed, Shaded Drawing (B & W; Group IV)	3.97	9.84	8.45
Detailed, Shaded Drawing (Color; Group V)	3.15	9.40	9.90
Heart Model (B & W; Group VI)	2.80	6.64	6.56
Heart Model (Color; Group VI)	3.43	7.27	7.57
Realistic Photographic (B & W; Group VIII)	2.44	5.54	6.00
Realistic Photographic (Color; Group IX)	1.86	5.87	5.99
Grand Mean		7.52	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 31 were obtained:

Table 31. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	2.01
$\mu I = \mu III$	Group I < Group III	4.11**
$\mu I = \mu IV$	Group I = Group IV	2.84
$\mu I = \mu V$	Group I < Group V	4.87**
$\mu I = \mu VI$	Group I = Group VI	0.50
$\mu I = \mu VII$	Group I = Group VII	1.83
$\mu I = \mu VIII$	Group I = Group VIII	0.20
$\mu I = \mu IX$	Group I = Group IX	0.22
$\mu II = \mu III$	Group II = Group III	1.89
$\mu II = \mu IV$	Group II = Group IV	0.76
$\mu II = \mu V$	Group II = Group V	2.55
$\mu II = \mu VI$	Group II = Group VI	1.45
$\mu II = \mu VII$	Group II = Group VII	0.28
$\mu II = \mu VIII$	Group II = Group VIII	2.16
$\mu II = \mu IX$	Group II = Group IX	2.22
$\mu III = \mu IV$	Group III = Group IV	1.13
$\mu III = \mu V$	Group III = Group V	0.66
$\mu III = \mu VI$	Group III = Group VI	3.41
$\mu III = \mu VII$	Group III = Group VII	2.29
$\mu III = \mu VIII$	Group III > Group VIII	4.21*
$\mu III = \mu IX$	Group III > Group IX	4.33*
$\mu IV = \mu V$	Group IV = Group V	1.78
$\mu IV = \mu VI$	Group IV = Group VI	2.23
$\mu IV = \mu VII$	Group IV = Group VII	1.08
$\mu IV = \mu VIII$	Group IV = Group VIII	2.97
$\mu IV = \mu IX$	Group IV = Group IX	3.05
$\mu V = \mu VI$	Group V > Group VI	4.11**
$\mu V = \mu VII$	Group V = Group VII	3.01
$\mu V = \mu VIII$	Group V > Group VIII	4.94**
$\mu V = \mu IX$	Group V > Group IX	5.09**
$\mu VI = \mu VII$	Group VI = Group VII	1.24
$\mu VI = \mu VIII$	Group VI = Group VIII	0.68
$\mu VI = \mu IX$	Group VI = Group IX	0.71
$\mu VII = \mu VIII$	Group VII = Group VIII	1.99
$\mu VII = \mu IX$	Group VII = Group IX	2.06
$\mu VIII = \mu IX$	Group VIII = Group IX	0.01

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Tenth Grade Treatment Groups on the Comprehension Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=17.69). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 32 and 33)

Table 32. Analysis of Variance and Covariance of the Comprehension Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	1091.87	136.48	13.13**	8	1181.69	147.71	17.69**
Within Groups	243	2525.11	10.39		242	2020.13	8.35	
Total	251	3616.99			250	3201.82		

**Significant at the 0.01 level.

Table 33. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Comprehension Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.39	9.77	10.03
Abstract Line (B & W; Group II)	3.62	12.42	12.05
Abstract Line (Color; Group III)	4.43	12.21	12.09
Detailed, Shaded Drawing (B & W; Group IV)	3.69	9.32	7.94
Detailed, Shaded Drawing (Color; Group V)	3.49	12.50	13.00
Heart Model (B & W; Group VI)	2.33	6.88	6.80
Heart Model (Color; Group VII)	2.36	6.57	6.86
Realistic Photographic (B & W; Gropu VIII)	2.92	10.79	11.25
Realistic Photographic (Color; Group IX)	3.26	10.13	10.25
Grand Mean		10.06	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 34 were obtained:

Table 34. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	2.57
$\mu I = \mu III$	Group I = Group III	2.73
$\mu I = \mu IV$	Group I = Group IV	2.69
$\mu I = \mu V$	Group I < Group V	4.01**
$\mu I = \mu VI$	Group I < Group VI	4.16**
$\mu I = \mu VII$	Group I < Group VII	4.28**
$\mu I = \mu VIII$	Group I = Group VIII	1.62
$\mu I = \mu IX$	Group I = Group IX	0.30
$\mu II = \mu III$	Group II = Group III	0.05
$\mu II = \mu IV$	Group II > Group IV	4.98**
$\mu II = \mu V$	Group II = Group V	1.20
$\mu II = \mu VI$	Group II > Group VI	6.36**
$\mu II = \mu VII$	Group II > Group VII	6.56**
$\mu II = \mu VIII$	Group II = Group VIII	1.00
$\mu II = \mu IX$	Group II = Group IX	2.29
$\mu III = \mu IV$	Group III > Group IV	5.22**
$\mu III = \mu V$	Group III = Group V	1.20
$\mu III = \mu VI$	Group III > Group VI	6.65**
$\mu III = \mu VII$	Group III > Group VII	6.89**
$\mu III = \mu VIII$	Group III = Group VIII	1.09
$\mu III = \mu IX$	Group III = Group IX	2.44
$\mu IV = \mu V$	Group IV < Group V	6.47**
$\mu IV = \mu VI$	Group IV = Group VI	1.39
$\mu IV = \mu VII$	Group IV = Group VII	1.38
$\mu IV = \mu VIII$	Group IV < Group VIII	4.16**
$\mu IV = \mu IX$	Group IV = Group IX	2.97
$\mu V = \mu VI$	Group V > Group VI	7.92**
$\mu V = \mu VII$	Group V > Group VII	8.23**
$\mu V = \mu VIII$	Group V = Group VIII	2.30
$\mu V = \mu IX$	Group V > Group IX	3.72*
$\mu VI = \mu VII$	Group VI = Group VII	0.08
$\mu VI = \mu VIII$	Group VI < Group VIII	5.60**
$\mu VI = \mu IX$	Group VI < Group IX	4.44**
$\mu VII = \mu VIII$	Group VII < Group VIII	5.78**
$\mu VII = \mu IX$	Group VII < Group IX	4.58**
$\mu VIII = \mu IX$	Group VIII = Group IX	1.33

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Eleventh Grade Treatment Groups on the Total Criterion Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=4.40). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 35 and 36)

Table 35. Analysis of Variance and Covariance of the Immediate Total Criterion Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	5807.47	725.93	4.79**	8	4092.25	511.53	4.40**
Within Groups	255	38633.08	151.50		254	29501.12	116.15	
Total	263	44440.55			262	33593.37		

**Significant at the 0.01 level.

Table 36. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Total Criterion Test.

Treatment	n	s.d.	Mean Physiology Test Scores Initial	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	31	7.35	14.94	24.97	26.72
Abstract Line Presentation (B & W; Group II)	32	16.84	16.31	38.44	38.41
Abstract Line Presentation (Color; Group III)	24	9.84	15.04	36.83	38.45
Detailed, Shaded Drawing Presentation (B & W; Group IV)	32	13.09	17.31	36.41	35.09
Detailed, Shaded Drawing Presentation (Color; Group V)	33	13.67	15.52	41.18	39.60
Heart Model Presentation (B & W; Group VI)	30	11.69	16.80	31.77	31.11
Heart Model Presentation (Color; Group VII)	22	9.41	17.64	35.18	33.44
Realistic Photographic Presentation (B & W; Group VIII)	33	14.57	16.85	37.66	36.95
Realistic Photographic Presentation (Color; Group IX)	27	8.94	13.89	31.37	34.48
Grand Mean			16.29	34.96	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 37 were obtained:

Table 37. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	4.30**
$\mu I = \mu III$	Group I < Group III	4.00**
$\mu I = \mu IV$	Group I = Group IV	3.08
$\mu I = \mu V$	Group I < Group V	4.78**
$\mu I = \mu VI$	Group I = Group VI	1.59
$\mu I = \mu VII$	Group I = Group VII	2.24
$\mu I = \mu VIII$	Group I < Group VIII	3.80*
$\mu I = \mu IX$	Group I = Group IX	2.74
$\mu II = \mu III$	Group II = Group III	0.01
$\mu II = \mu IV$	Group II = Group IV	1.23
$\mu II = \mu V$	Group II = Group V	0.45
$\mu II = \mu VI$	Group II = Group VI	2.67
$\mu II = \mu VII$	Group II = Group VII	1.67
$\mu II = \mu VIII$	Group II = Group VIII	0.55
$\mu II = \mu IX$	Group II = Group IX	1.40
$\mu III = \mu IV$	Group III = Group IV	1.15
$\mu III = \mu V$	Group III = Group V	0.40
$\mu III = \mu VI$	Group III = Group VI	2.49
$\mu III = \mu VII$	Group III = Group VII	1.57
$\mu III = \mu VIII$	Group III = Group VIII	0.52
$\mu III = \mu IX$	Group III = Group IX	1.31
$\mu IV = \mu V$	Group IV = Group V	1.69
$\mu IV = \mu VI$	Group IV = Group VI	1.45
$\mu IV = \mu VII$	Group IV = Group VII	0.55
$\mu IV = \mu VIII$	Group IV = Group VIII	0.70
$\mu IV = \mu IX$	Group IV = Group IX	0.22
$\mu V = \mu VI$	Group V = Group VI	3.12
$\mu V = \mu VII$	Group V = Group VII	2.08
$\mu V = \mu VIII$	Group V = Group VIII	1.00
$\mu V = \mu IX$	Group V = Group IX	1.83
$\mu VI = \mu VII$	Group VI = Group VII	0.77
$\mu VI = \mu VIII$	Group VI = Group VIII	2.15
$\mu VI = \mu IX$	Group VI = Group IX	1.18
$\mu VII = \mu VIII$	Group VII = Group VIII	1.18
$\mu VII = \mu IX$	Group VII = Group IX	0.34
$\mu VIII = \mu IX$	Group VIII = Group IX	0.88

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Eleventh Grade Treatment Groups on the Drawing Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=3.75). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 38 and 39)

Table 38. Analysis of Variance and Covariance of the Drawing Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	774.74	96.84	3.99**	8	638.29	79.79	3.75**
Among Groups	255	6186.25	24.26		254	5398.83	21.26	
Total	263	6960.99			262	6037.12		

**Signifiant at the 0.01 level.

Table 39. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Drawing Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.18	4.26	4.77
Abstract Line (B & W; Group II)	8.75	10.38	10.36
Abstract Line (Color; Group III)	3.80	9.00	9.48
Detailed, Shaded Drawing (B & W; Group IV)	3.80	8.31	7.92
Detailed, Shaded Drawing (Color; Group V)	4.87	9.42	8.96
Heart Model (B & W; Group VI)	3.99	7.07	6.87
Heart Model (Color; Group VII)	4.40	8.95	8.44
Realistic Photographic (B & W; Group VIII)	4.56	7.61	7.39
Realistic Photographic (Color; Group IX)	4.11	7.26	8.17
Grand Mean		8.00	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 40 were obtained:

Table 40. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	4.81**
$\mu I = \mu III$	Group I < Group III	3.76*
$\mu I = \mu IV$	Group I = Group IV	2.71
$\mu I = \mu V$	Group I < Group V	3.63*
$\mu I = \mu VI$	Group I = Group VI	1.78
$\mu I = \mu VII$	Group I = Group VII	2.86
$\mu I = \mu VIII$	Group I = Group VIII	2.27
$\mu I = \mu IX$	Group I = Group IX	2.80
$\mu II = \mu III$	Group II = Group III	0.71
$\mu II = \mu IV$	Group II = Group IV	2.12
$\mu II = \mu V$	Group II = Group V	1.22
$\mu II = \mu VI$	Group II = Group VI	2.98
$\mu II = \mu VII$	Group II = Group VII	1.50
$\mu II = \mu VIII$	Group II = Group VIII	2.60
$\mu II = \mu IX$	Group II = Group IX	1.82
$\mu III = \mu IV$	Group III = Group IV	1.25
$\mu III = \mu V$	Group III = Group V	0.42
$\mu III = \mu VI$	Group III = Group VI	2.07
$\mu III = \mu VII$	Group III = Group VII	0.76
$\mu III = \mu VIII$	Group III = Group VIII	1.69
$\mu III = \mu IX$	Group III = Group IX	1.01
$\mu IV = \mu V$	Group IV = Group V	0.91
$\mu IV = \mu VI$	Group IV = Group VI	0.90
$\mu IV = \mu VII$	Group IV = Group VII	0.41
$\mu IV = \mu VIII$	Group IV = Group VIII	0.46
$\mu IV = \mu IX$	Group IV = Group IX	0.21
$\mu V = \mu VI$	Group V = Group VI	1.80
$\mu V = \mu VII$	Group V = Group VII	0.41
$\mu V = \mu VIII$	Group V = Group VIII	1.38
$\mu V = \mu IX$	Group V = Group IX	0.66
$\mu VI = \mu VII$	Group VI = Group VII	1.21
$\mu VI = \mu VIII$	Group VI = Group VIII	0.45
$\mu VI = \mu IX$	Group VI = Group IX	1.06
$\mu VII = \mu VIII$	Group VII = Group VIII	0.83
$\mu VII = \mu IX$	Group VII = Group IX	0.20
$\mu VIII = \mu IX$	Group VIII = Group IX	0.65

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Eleventh Grade Treatment Groups on the Identification Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=4.81). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 41 and 42)

Table 41. Analysis of Variance and Covariance of the Identification Test Scores for the Nine Treatment Groups.

Variance	Original Analysis D.F.	Original Analysis Sum of Squares	Original Analysis Mean Square	Original Analysis F	Adjusted Analysis D.F.	Adjusted Analysis Sum of Squares	Adjusted Analysis Mean Square	Adjusted Analysis F
Among Groups	8	645.16	80.65	4.95**	8	573.84	71.73	4.81**
Within Groups	255	4153.84	16.29		254	3784.01	14.90	
Total	263	4799.00			262	4357.85		

**Significant at the 0.01 level.

Table 42. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Identification Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.54	6.06	6.42
Abstract Line (B & W; Group II)	4.80	9.91	9.90
Abstract Line (Color; Group III)	3.78	9.29	9.62
Detailed, Shaded Drawing (B & W; Group IV)	4.30	8.03	7.77
Detailed, Shaded Drawing (Color; Group V)	4.41	11.73	11.41
Heart Model (B & W; Group VI)	4.10	8.13	8.00
Heart Model (Color; Group VII)	3.30	7.95	7.60
Realistic Photographic (B & W; Group VIII)	4.19	9.91	9.76
Realistic Photographic (Color; Group IX)	4.13	8.70	9.33
Grand Mean		8.91	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 43 were obtained:

Table 43. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	3.58*
$\mu I = \mu III$	Group I = Group III	3.05
$\mu I = \mu IV$	Group I = Group IV	1.39
$\mu I = \mu V$	Group I < Group V	5.17**
$\mu I = \mu VI$	Group I = Group VI	1.60
$\mu I = \mu VII$	Group I = Group VII	1.10
$\mu I = \mu VIII$	Group I < Group VIII	3.46*
$\mu I = \mu IX$	Group I = Group IX	2.86
$\mu II = \mu III$	Group II = Group III	0.27
$\mu II = \mu IV$	Group II = Group IV	2.21
$\mu II = \mu V$	Group II = Group V	1.58
$\mu II = \mu VI$	Group II = Group VI	1.94
$\mu II = \mu VII$	Group II = Group VII	2.15
$\mu II = \mu VIII$	Group II = Group VIII	0.15
$\mu II = \mu IX$	Group II = Group IX	0.57
$\mu III = \mu IV$	Group III = Group IV	1.77
$\mu III = \mu V$	Group III = Group V	1.73
$\mu III = \mu VI$	Group III = Group VI	1.53
$\mu III = \mu VII$	Group III = Group VII	1.77
$\mu III = \mu VIII$	Group III = Group VIII	0.14
$\mu III = \mu IX$	Group III = Group IX	0.27
$\mu IV = \mu V$	Group IV < Group V	3.80*
$\mu IV = \mu VI$	Group IV = Group VI	0.23
$\mu IV = \mu VII$	Group IV = Group VII	0.16
$\mu IV = \mu VIII$	Group IV = Group VIII	2.08
$\mu IV = \mu IX$	Group IV = Group IX	1.55
$\mu V = \mu VI$	Group V > Group VI	3.50*
$\mu V = \mu VII$	Group V > Group VII	3.59*
$\mu V = \mu VIII$	Group V = Group VIII	1.74
$\mu V = \mu IX$	Group V = Group IX	2.08
$\mu VI = \mu VII$	Group VI = Group VII	0.37
$\mu VI = \mu VIII$	Group VI = Group VIII	1.81
$\mu VI = \mu IX$	Group VI = Group IX	1.30
$\mu VII = \mu VIII$	Group VII = Group VIII	2.03
$\mu VII = \mu IX$	Group VII = Group IX	1.56
$\mu VIII = \mu IX$	Group VIII = Group IX	0.43

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Eleventh Grade Treatment Groups on the Terminology Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 44 and 45)

Table 44. Analysis of Variance and Covariance of the Terminology Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	230.67	28.83	2.17*	8	109.46	13.68	1.29
Within Groups	255	3383.66	13.27		254	2697.23	10.62	
Total	263	3414.33			262	2806.69		

*Significant at the 0.05 level.

Table 45. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Terminology Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.45	5.61	6.09
Abstract Line (B & W; Group II)	4.49	7.44	7.43
Abstract Line (Color; Group III)	2.19	7.54	7.99
Detailed, Shaded Drawing (B & W; Group IV)	3.89	8.50	8.14
Detailed, Shaded Drawing (Color; Group V)	3.82	8.15	7.72
Heart Model (B & W; Group VI)	3.09	7.00	6.82
Heart Model (Color; Group VII)	3.72	7.86	7.39
Realistic Photographic (B & W; Group VIII)	5.27	8.30	8.11
Realistic Photographic (Color; Group IX)	1.76	6.22	7.07
Grand Mean		7.42	

Comparison of the Eleventh Grade Treatment Groups on the Comprehension Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=4.97). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 46 and 47)

Table 46. Analysis of Variance and Covariance of the Comprehension Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	552.52	60.07	6.42**	8	334.15	41.77	4.97**
Within Groups	255	2742.63	10.76		254	2134.29	8.40	
Total	263	3295.15			262	2468.44		

**Significant at the 0.01 level.

Table 47. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Comprehension Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.15	9.03	9.48
Abstract Line (B & W; Group II)	3.56	11.59	11.59
Abstract Line (Color; Group III)	3.26	10.92	11.33
Detailed, Shaded Drawing (B & W; Group IV)	3.95	11.56	11.22
Detailed, Shaded Drawing (Color; Group V)	3.07	11.88	11.47
Heart Model (B & W; Group VI)	3.20	9.93	9.76
Heart Model (Color; Group VII)	3.47	10.86	10.41
Realistic Photographic (B & W; Group VIII)	3.82	11.55	11.36
Realistic Photographic (Color; Group IX)	2.51	7.19	7.99
Grand Mean		10.56	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 48 were obtained:

Table 48. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	2.89
$\mu I = \mu III$	Group I = Group III	2.35
$\mu I = \mu IV$	Group I = Group IV	2.38
$\mu I = \mu V$	Group I = Group V	2.75
$\mu I = \mu VI$	Group I = Group VI	0.38
$\mu I = \mu VII$	Group I = Group VII	1.15
$\mu I = \mu VIII$	Group I = Group VIII	2.59
$\mu I = \mu IX$	Group I = Group IX	1.95
$\mu II = \mu III$	Group II = Group III	0.33
$\mu II = \mu IV$	Group II = Group IV	0.51
$\mu II = \mu V$	Group II = Group V	0.17
$\mu II = \mu VI$	Group II = Group VI	2.48
$\mu II = \mu VII$	Group II = Group VII	1.47
$\mu II = \mu VIII$	Group II = Group VIII	0.32
$\mu II = \mu IX$	Group II > Group IX	4.75**
$\mu III = \mu IV$	Group III = Group IV	0.14
$\mu III = \mu V$	Group III = Group V	0.18
$\mu III = \mu VI$	Group III = Group VI	1.98
$\mu III = \mu VII$	Group III = Group VII	1.08
$\mu III = \mu VIII$	Group III = Group VIII	0.04
$\mu III = \mu IX$	Group III > Group IX	4.11**
$\mu IV = \mu V$	Group IV = Group V	0.35
$\mu IV = \mu VI$	Group IV = Group VI	1.98
$\mu IV = \mu VII$	Group IV = Group VII	1.01
$\mu IV = \mu VIII$	Group IV = Group VIII	0.19
$\mu IV = \mu IX$	Group IV > Group IX	4.26**
$\mu V = \mu VI$	Group V = Group VI	2.34
$\mu V = \mu VII$	Group V = Group VII	1.33
$\mu V = \mu VIII$	Group V = Group VIII	0.15
$\mu V = \mu IX$	Group V > Group IX	4.63**
$\mu VI = \mu VII$	Group VI = Group VII	0.80
$\mu VI = \mu VIII$	Group VI = Group VIII	2.19
$\mu VI = \mu IX$	Group VI = Group IX	2.30
$\mu VII = \mu VIII$	Group VII = Group VIII	1.19
$\mu VII = \mu IX$	Group VII = Group IX	2.91
$\mu VIII = \mu IX$	Group VIII = Group IX	4.48**

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Twelfth Grade Treatment Groups on the Total Criterion Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=7.86). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 49 and 50)

Table 49. Analysis of Variance and Covariance of the Immediate Total Criterion Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	5190.40	738.80	4.19**	8	7908.85	988.61	7.86**
Within Groups	253	44642.99	176.45		252	31997.52	126.97	
Total	261	50553.39			260	39906.37		

**Significant at the 0.01 level.

Table 50. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Total Criterion Test.

Treatment	n	s.d.	Mean Physiology Test Scores Initial	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	20	11.48	19.75	37.35	38.56
Abstract Line Presentation (B & W; Group II)	30	13.97	22.13	43.10	41.08
Abstract Line Presentation (Color; Group III)	31	9.86	24.42	44.32	39.19
Detailed, Shaded Drawing Presentation (B & W; Group IV)	37	16.28	19.97	47.84	48.75
Detailed, Shaded Drawing Presentation (Color; Group V)	29	6.93	19.07	56.03	58.18
Heart Model Presentation (B & W; Group VI)	36	12.28	18.25	44.56	47.81
Heart Model Presentation (Color; Group VII)	31	14.83	19.55	42.94	44.42
Realistic Photographic Presentation (B & W; Group VIII)	29	15.11	19.79	42.24	43.40
Realistic Photographic Presentation (Color; Group IX)	19	15.75	24.42	51.57	46.44
Grand Mean			20.65	45.61	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 51 were obtained:

Table 51. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	0.77
$\mu I = \mu III$	Group I = Group III	0.19
$\mu I = \mu IV$	Group I = Group IV	3.26
$\mu I = \mu V$	Group I < Group V	5.99*
$\mu I = \mu VI$	Group I = Group VI	2.94
$\mu I = \mu VII$	Group I = Group VII	1.82
$\mu I = \mu VIII$	Group I = Group VIII	1.48
$\mu I = \mu IX$	Group I = Group IX	2.18
$\mu II = \mu III$	Group II = Group III	0.65
$\mu II = \mu IV$	Group II = Group IV	2.77
$\mu II = \mu V$	Group II < Group V	5.83**
$\mu II = \mu VI$	Group II = Group VI	2.42
$\mu II = \mu VII$	Group II = Group VII	1.16
$\mu II = \mu VIII$	Group II = Group VIII	0.79
$\mu II = \mu IX$	Group II = Group IX	1.62
$\mu III = \mu IV$	Group III < Group IV	3.48*
$\mu III = \mu V$	Group III < Group V	6.52**
$\mu III = \mu VI$	Group III = Group VI	3.12
$\mu III = \mu VII$	Group III = Group VII	1.83
$\mu III = \mu VIII$	Group III = Group VIII	1.45
$\mu III = \mu IX$	Group III = Group IX	2.21
$\mu IV = \mu V$	Group IV < Group V	3.37*
$\mu IV = \mu VI$	Group IV = Group VI	0.36
$\mu IV = \mu VII$	Group IV = Group VII	1.57
$\mu IV = \mu VIII$	Group IV = Group VIII	1.91
$\mu IV = \mu IX$	Group IV = Group IX	0.73
$\mu V = \mu VI$	Group V > Group VI	3.69*
$\mu V = \mu VII$	Group V > Group VII	4.72**
$\mu V = \mu VIII$	Group V > Group VIII	4.99**
$\mu V = \mu IX$	Group V > Group IX	3.53*
$\mu VI = \mu VII$	Group VI = Group VII	1.22
$\mu VI = \mu VIII$	Group VI = Group VIII	1.57
$\mu VI = \mu IX$	Group VI = Group IX	0.43
$\mu VII = \mu VIII$	Group VII = Group VIII	0.35
$\mu VII = \mu IX$	Group VII = Group IX	0.61
$\mu VIII = \mu IX$	Group VIII = Group IX	0.91

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Twelfth Grade Treatment Groups on the Drawing Test

The F-ratio does not exceed the critical value required for the 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 52 and 53)

Table 52. Analysis of Variance and Covariance of the Drawing Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	273.20	34.15	1.85	8	224.45	28.06	1.85
Within Groups	253	4660.30	18.42		252	3827.37	15.19	
Total	261	4933.50			260	4051.81		

Total 53. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Drawing Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	4.15	9.40	9.70
Abstract Line (B & W; Group II)	4.31	11.63	11.13
Abstract Line (Color; Group III)	3.71	12.00	10.73
Detailed, Shaded Drawing (B & W; Group IV)	4.63	11.59	11.82
Detailed, Shaded Drawing (Color; Group V)	3.91	12.76	13.29
Heart Model (B & W; Group VI)	3.70	11.17	11.98
Heart Model (Color; Group VII)	4.17	10.77	11.14
Realistic Photographic (B & W; Group VIII)	5.36	10.76	11.05
Realistic Photographic (Color; Group IX)	4.57	13.89	12.62
Grand Mean		11.53	

Comparison of the Twelfth Grade Treatment Groups on the Identification Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=4.92). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 54 and 55)

Table 54. Analysis of Variance and Covariance of the Identification Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	405.66	50.71	2.83**	8	572.54	71.57	4.92**
Within Groups	253	4538.35	17.94		252	3669.51	14.56	
Total	261	4944.01			260	4242.05		

**Significant at the 0.01 level.

Table 55. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Identification Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.57	9.40	9.72
Abstract Line (B & W; Group II)	4.22	9.93	9.41
Abstract Line (Color; Group III)	3.87	10.13	8.79
Detailed, Shaded Drawing (B & W; Group IV)	4.72	11.68	11.91
Detailed, Shaded Drawing (Color; Group V)	3.87	13.10	13.66
Heart Model (B & W; Group VI)	3.67	11.47	12.32
Heart Model (Color; Group VII)	4.98	10.65	11.03
Realistic Photographic (B & W; Group VIII)	4.26	9.55	9.85
Realistic Photographic (Color; Group IX)	4.67	12.95	11.61
Grand Mean		10.98	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 56 were obtained:

Table 56. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	0.28
$\mu I = \mu III$	Group I = Group III	0.85
$\mu I = \mu IV$	Group I = Group IV	2.07
$\mu I = \mu V$	Group I < Group V	3.55**
$\mu I = \mu VI$	Group I = Group VI	2.44
$\mu I = \mu VII$	Group I = Group VII	1.20
$\mu I = \mu VIII$	Group I = Group VIII	0.12
$\mu I = \mu IX$	Group I = Group IX	1.55
$\mu II = \mu III$	Group II = Group III	0.63
$\mu II = \mu IV$	Group II = Group IV	2.67
$\mu II = \mu V$	Group II < Group V	4.28*
$\mu II = \mu VI$	Group II = Group VI	3.08
$\mu II = \mu VII$	Group II = Group VII	1.66
$\mu II = \mu VIII$	Group II = Group VIII	0.44
$\mu II = \mu IX$	Group II = Group IX	1.97
$\mu III = \mu IV$	Group III < Group IV	3.36**
$\mu III = \mu V$	Group III < Group V	4.96*
$\mu III = \mu VI$	Group III < Group VI	3.78**
$\mu III = \mu VII$	Group III = Group VII	2.31
$\mu III = \mu VIII$	Group III = Group VIII	1.08
$\mu III = \mu IX$	Group III = Group IX	2.54
$\mu IV = \mu V$	Group IV = Group V	1.85
$\mu IV = \mu VI$	Group IV = Group VI	0.46
$\mu IV = \mu VII$	Group IV = Group VII	0.95
$\mu IV = \mu VIII$	Group IV = Group VIII	2.18
$\mu IV = \mu IX$	Group IV = Group IX	0.28
$\mu V = \mu VI$	Group V = Group VI	1.41
$\mu V = \mu VII$	Group V = Group VII	2.67
$\mu V = \mu VIII$	Group V > Group VIII	3.80**
$\mu V = \mu IX$	Group V = Group IX	1.82
$\mu VI = \mu VII$	Group VI = Group VII	1.38
$\mu VI = \mu VIII$	Group VI = Group VIII	2.59
$\mu VI = \mu IX$	Group VI = Group IX	0.66
$\mu VII = \mu VIII$	Group VII = Group VIII	1.20
$\mu VII = \mu IX$	Group VII = Group IX	0.52
$\mu VIII = \mu IX$	Group VIII = Group IX	1.56

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Twelfth Grade Treatment Groups on the Terminology Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=8.82). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 57 and 58)

Table 57. Analysis of Variance and Covariance of the Terminology Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	M Square	F
Among Groups	8	852.76	106.60	5.13**	8	1130.11	141.26	8.82**
Within Groups	253	5252.66	20.76		252	4037.86	16.02	
Total	261	6105.42			260	5167.97		

**Significant at the 0.01 level.

Table 58. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Terminology Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.80	7.50	7.89
Abstract Line (B & W; Group II)	4.62	9.30	8.65
Abstract Line (Color; Group III)	4.40	9.45	7.80
Detailed, Shaded Drawing (B & W; Group IV)	5.18	10.97	11.27
Detailed, Shaded Drawing (Color; Group V)	3.84	14.66	15.35
Heart Model (B & W; Group VI)	4.38	9.61	10.66
Heart Model (Color; Group VII)	4.40	9.39	9.87
Realistic Photograph (B & W; Group VIII)	4.74	10.24	10.62
Realistic Photograph (Color; Group IX)	5.40	11.68	10.03
Grand Mean		10.34	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 59 were obtained:

Table 59. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	0.66
$\mu I = \mu III$	Group I = Group III	0.08
$\mu I = \mu IV$	Group I = Group IV	3.04
$\mu I = \mu V$	Group I < Group V	6.41**
$\mu I = \mu VI$	Group I = Group VI	2.48
$\mu I = \mu VII$	Group I = Group VII	1.72
$\mu I = \mu VIII$	Group I = Group VIII	2.35
$\mu I = \mu IX$	Group I = Group IX	1.67
$\mu II = \mu III$	Group II = Group III	0.83
$\mu II = \mu IV$	Group II = Group IV	2.66
$\mu II = \mu V$	Group II < Group V	6.43**
$\mu II = \mu VI$	Group II = Group VI	2.03
$\mu II = \mu VII$	Group II = Group VII	1.19
$\mu II = \mu VIII$	Group II = Group VIII	1.89
$\mu II = \mu IX$	Group II = Group IX	1.18
$\mu III = \mu IV$	Group III < Group IV	3.56*
$\mu III = \mu V$	Group III < Group V	7.30**
$\mu III = \mu VI$	Group III = Group VI	2.92
$\mu III = \mu VII$	Group III = Group VII	2.04
$\mu III = \mu VIII$	Group III = Group VIII	2.73
$\mu III = \mu IX$	Group III = Group IX	1.91
$\mu IV = \mu V$	Group IV < Group V	4.11**
$\mu IV = \mu VI$	Group IV = Group VI	0.65
$\mu IV = \mu VII$	Group IV = Group VII	1.44
$\mu IV = \mu VIII$	Group IV = Group VIII	0.65
$\mu IV = \mu IX$	Group IV = Group IX	1.10
$\mu V = \mu VI$	Group V > Group VI	4.70**
$\mu V = \mu VII$	Group V > Group VII	5.30**
$\mu V = \mu VIII$	Group V > Group VIII	4.50**
$\mu V = \mu IX$	Group V > Group IX	4.50**
$\mu VI = \mu VII$	Group VI = Group VII	0.81
$\mu VI = \mu VIII$	Group VI = Group VIII	0.04
$\mu VI = \mu IX$	Group VI = Group IX	0.56
$\mu VII = \mu VIII$	Group VII = Group VIII	0.73
$\mu VII = \mu IX$	Group VII = Group IX	0.14
$\mu VIII = \mu IX$	Group VIII = Group IX	0.50

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Twelfth Grade Treatment Groups on the Comprehension Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=5.56). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 60 and 61)

Table 60. Analysis of Variance and Covariance of the Comprehension Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	M Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	416.12	52.02	4.51**	8	429.75	53.72	5.56**
Within Groups	253	2920.57	11.54		252	2434.48	9.66	
Total	261	3336.69			260	2864.23		

**Significant at the 0.01 level.

Total 61. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Comprehension Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.35	10.85	11.06
Abstract Line (B & W; Group II)	3.77	12.60	12.26
Abstract Line (Color; Group III)	2.97	12.74	11.87
Detailed, Shaded Drawing (B & W; Group IV)	3.62	13.76	13.91
Detailed, Shaded Drawing (Color; Group V)	3.36	15.52	15.88
Heart Model (B & W; Group VI)	3.49	12.72	13.28
Heart Model (Color; Group VII)	3.34	12.13	12.38
Realistic Photograph (B & W; Group VIII)	3.58	11.93	12.13
Realistic Photograph (Color; Group IV)	3.67	13.58	12.70
Grand Mean		12.93	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown on Table 62 were obtained:

Table 62. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
μI = μII	Group I = Group II	1.34
μI = μIII	Group I = Group III	0.91
μI = μIV	Group I = Group IV	3.30
μI = μV	Group I < Group V	5.34**
μI = μVI	Group I = Group VI	2.56
μI = μVII	Group I = Group VII	1.48
μI = μVIII	Group I = Group VIII	1.18
μI = μIX	Group I = Group IX	1.65
μII = μIII	Group II = Group III	0.49
μII = μIV	Group II = Group IV	2.16
μII = μV	Group II < Group V	4.47**
μII = μVI	Group II = Group VI	1.33
μII = μVII	Group II = Group VII	0.15
μII = μVIII	Group II = Group VIII	0.16
μII = μIX	Group II = Group IX	0.48
μIII = μIV	Group III = Group IV	2.70
μIII = μV	Group III < Group V	4.99**
μIII = μVI	Group III = Group VI	1.85
μIII = μVII	Group III = Group VII	0.65
μIII = μVIII	Group III = Group VIII	0.32
μIII = μIX	Group III = Group IX	0.92
μIV = μV	Group IV = Group V	2.56
μIV = μVI	Group IV = Group VI	0.87
μIV = μVII	Group IV = Group VII	2.02
μIV = μVIII	Group IV = Group VIII	2.31
μIV = μIX	Group IV = Group IX	1.38
μV = μVI	Group V > Group VI	3.35*
μV = μVII	Group V > Group VII	4.36**
μV = μVIII	Group V > Group VIII	4.59**
μV = μIX	Group V > Group IX	3.47*
μVI = μVII	Group VI = Group VII	1.18
μVI = μVIII	Group VI = Group VIII	1.48
μVI = μIX	Group VI = Group IX	0.66
μVII = μVIII	Group VII = Group VIII	0.31
μVII = μIX	Group VII = Group IX	0.35
μVIII = μIX	Group VIII = Group IX	0.62

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

B. Delayed Retention Analysis

Introduction

The number of students who participated in the immediate retention testing was 1,054. The number of students involved in the delayed retention testing was 1,000 ; this reduction was caused by student absenteeism (see Tables 63, 64, 65 and 66).

An analysis of covariance was conducted on the data obtained from the delayed retention tests with the immediate retention test scores being used as the adjusting variable. This technique eliminates the differences among groups due to treatment effects, and renders them relatively equivalent in terms of retention. The variable affecting the delayed retention test scores would then be the amount of time between the immediate and delayed retention test. This technique was used to determine whether significant differences in retention occurred in the time lapse between the immediate and delayed testing sessions.

The Pearson $\underline{r}$ between the immediate total retention test scores and the delayed total retention test scores for the ninth, tenth, eleventh, and twelfth grades was .85, .86, .85 and .85 respectively. These correlations are significantly different from zero at the 0.01 level.

Table 63. Assignment of Ninth Grade Students Available for the Delayed Retention Testing.

	Male	Female	Total
Oral Presentation: Group I	14	17	31
Abstract Line (B & W): Group II	17	14	31
Abstract Line (Color): Group III	16	14	30
Detailed, Shaded Drawing (B & W): Group IV	12	16	28
Detailed, Shaded Drawing (Color): Group V	12	13	25
Heart Model (B & W): Group VI	17	14	31
Heart Model (Color): Group VII	14	15	29
Realistic Photographic (B & W): Group VIII	16	17	33
Realistic Photographic (Color): Group IX	16	13	29
Total	134	133	267

Table 64. Assignment of Tenth Grade Students Available for the Delayed Retention Testing.

	Male	Female	Total
Oral Presentation: Group I	18	13	31
Abstract Line (B & W): Group II	9	13	22
Abstract Line (Color): Group III	16	11	27
Detailed, Shaded Drawing (B & W): Group IV	11	10	21
Detailed, Shaded Drawing (Color): Group V	14	14	28
Heart Model (B & W): Group VI	14	9	23
Heart Model (Color): Group VII	7	18	25
Realistic Photographic (B & W): Group VIII	12	15	27
Realistic Photographic (Color): Group IX	20	10	30
Total	121	113	234

Table 65. Assignment of Eleventh Grade Students Available for the Delayed Retention Testing.

	Male	Female	Total
Oral Presentation: Group I	17	14	31
Abstract Line (B & W): Group II	19	12	31
Abstract Line (Color): Group III	9	13	22
Detailed, Shaded Drawing (B & W): Group IV	18	10	28
Detailed, Shaded Drawing (Color): Group V	14	18	32
Heart Model (B & W): Group VI	9	19	28
Heart Model (Color): Group VII	13	9	22
Realistic Photographic (B & W): Group VIII	19	14	33
Realistic Photographic (Color): Group IX	14	11	25
Total	132	120	252

Table 66. Assignment of Twelfth Grade Students Available for the Delayed Retention Testing.

	Male	Female	Total
Oral Presentation: Group I	4	14	18
Abstract Line (B & W): Group II	13	14	27
Abstract Line (Color): Group III	18	10	28
Detailed, Shaded Drawing (B & W): Group IV	17	19	36
Detailed, Shaded Drawing (Color): Group V	13	16	29
Heart Model (B & W): Group VI	20	14	34
Heart Model (Color): Group VII	23	7	30
Realistic Photographic (B & W): Group VIII	19	9	28
Realistic Photographic (Color): Group IX	7	10	17
Total	134	113	247

Delayed Testing

Comparison of the Ninth Grade Treatment Groups on the Delayed Total Criterion Retention Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified.

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 67 and 68)

Table 67. Analysis of Variance and Covariance of the Total Criterion Test Scores for the Nine Treatment Groups.

Variance	Original Analysis D.F.	Original Analysis Sum of Squares	Original Analysis Mean Square	Original Analysis F	Adjusted Analysis D.F.	Adjusted Analysis Sum of Squares	Adjusted Analysis Mean Square	Adjusted Analysis F
Among Groups	8	4679.58	584.94	3.86**	8	557.00	69.63	1.53
Within Groups	258	39125.13	151.65		257	11726.99	45.63	
Total	266	43804.71			265	12283.99		

**Significant at the 0.01 level.

Table 68. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Total Criterion Test.

Treatment	n	s.d.	Total Mean Test Score Immediate Retention	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	31	5.10	25.19	23.68	32.21
Abstract Line Presentation (B & W; Group II)	31	14.77	39.32	37.97	33.52
Abstract Line Presentation (Color; Group III)	30	15.32	35.20	31.73	31.07
Detailed, Shaded Drawing Presentation (B & W; Group IV)	28	10.87	35.18	31.61	30.96
Detailed, Shaded Drawing Presentation (Color; Group V)	25	14.44	39.24	35.72	31.34
Heart Model Presentation (B & W; Group VI)	31	11.49	32.52	33.52	35.32
Heart Model Presentation (Color; Group VII)	29	10.02	36.93	33.66	31.40
Realistic Photographic Presentation (B & W; Group VIII)	33	10.26	31.12	27.58	30.66
Realistic Photographic Presentation (Color; Group IX)	29	15.42	37.17	35.14	32.66
Grand Mean			34.48	32.15	

Comparison of the Ninth Grade Treatment Groups on the Delayed Retention Drawing Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.05 level test (F=2.32). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 69 and 70)

Table 69. Analysis of Variance and Covariance of the Drawing Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	832.50	104.06	5.70**	8	144.12	18.01	2.32*
Within Groups	258	4709.15	18.25		257	1992.54	7.75	
Total	266	5541.65			265	2136.66		

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 70. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Drawing Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.56	4.94	7.62
Abstract Line (B & W; Group II)	4.78	11.45	10.05
Abstract Line (Color; Group III)	6.23	10.23	10.02
Detailed, Shaded Drawing (B & W; Group IV)	4.24	8.96	8.76
Detailed, Shaded Drawing (Color; Group V)	5.34	10.16	8.78
Heart Model (B & W; Group VI)	3.53	9.23	9.79
Heart Model (Color; Group VII)	3.35	9.31	8.60
Realistic Photographic (B & W; Group VIII)	3.45	7.97	8.94
Realistic Photographic (Color; Group IX)	4.78	9.76	8.98
Grand Mean		9.07	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 71 were obtained:

Table 71. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I < Group II	3.44*
$\mu I = \mu III$	Group I < Group III	3.37*
$\mu I = \mu IV$	Group I = Group IV	1.57
$\mu I = \mu V$	Group I = Group V	1.55
$\mu I = \mu VI$	Group I = Group VI	3.07
$\mu I = \mu VII$	Group I = Group VII	1.36
$\mu I = \mu VIII$	Group I = Group VIII	1.90
$\mu I = \mu IX$	Group I = Group IX	1.89
$\mu II = \mu III$	Group II = Group III	0.04
$\mu II = \mu IV$	Group II = Group IV	1.78
$\mu II = \mu V$	Group II = Group V	1.70
$\mu II = \mu VI$	Group II = Group VI	0.37
$\mu II = \mu VII$	Group II = Group VII	2.02
$\mu II = \mu VIII$	Group II = Group VIII	1.59
$\mu II = \mu IX$	Group II = Group IX	1.49
$\mu III = \mu IV$	Group III = Group IV	1.72
$\mu III = \mu V$	Group III = Group V	1.64
$\mu III = \mu VI$	Group III = Group VI	0.32
$\mu III = \mu VII$	Group III = Group VII	1.96
$\mu III = \mu VIII$	Group III = Group VIII	1.54
$\mu III = \mu IX$	Group III = Group IX	1.43
$\mu IV = \mu V$	Group IV = Group V	0.03
$\mu IV = \mu VI$	Group IV = Group VI	1.42
$\mu IV = \mu VII$	Group IV = Group VI	0.22
$\mu IV = \mu VIII$	Group IV = Group VIII	0.25
$\mu IV = \mu IX$	Group IV = Group IX	0.30
$\mu V = \mu VI$	Group V = Group VI	1.35
$\mu V = \mu VII$	Group V = Group VII	0.24
$\mu V = \mu VIII$	Group V = Group VIII	0.22
$\mu V = \mu IX$	Group V = Group IX	0.26
$\mu VI = \mu VII$	Group VI = Group VII	1.65
$\mu VI = \mu VIII$	Group VI = Group VIII	1.22
$\mu VI = \mu IX$	Group VI = Group IX	1.13
$\mu VII = \mu VIII$	Group VII = Group VIII	0.48
$\mu VII = \mu IX$	Group VII = Group IX	0.52
$\mu VIII = \mu IX$	Group VIII = Group IX	0.06

*Significant at the 0.05 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Ninth Grade Treatment Groups on the Delayed Retention Identification Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 72 and 73)

Table 72. Analysis of Variance and Covariance of the Identification Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	302.89	37.86	2.57*	8	62.18	7.77	.93
Within Groups	258	3796.60	14.72		257	2158.62	8.40	
Total	266	4099.49			265	2220.80		

*Significant at the 0.05 level.

Table 73. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Identification Test.

Treatment	s.d.	Total Mean Test Score Original	Test Score Adjusted
Oral Presentation (Group I)	2.45	7.10	9.18
Abstract Line (B & W; Group II)	4.52	10.13	9.04
Abstract Line (Color; Group III)	4.29	7.67	7.50
Detailed, Shaded Drawing (B & W; Group IV)	4.07	8.86	8.70
Detailed, Shaded Drawing (Color; Group V)	4.59	10.20	9.13
Heart Model (B & W; Group VI)	3.37	8.23	8.67
Heart Model (Color; Group VII)	3.74	9.34	8.79
Realistic Photographic (B & W; Group VIII)	3.09	7.79	8.54
Realistic Photographic (Color; Group IX)	4.14	9.62	9.01
Grand Mean		8.72	

Comparison of the Ninth Grade Treatment Groups on the Delayed Retention Terminology Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.05 level test (F=2.25). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Table 74 and 75)

Table 74. Analysis of Variance and Covariance of the Terminology Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	233.35	29.17	2.14*	8	101.66	12.71	2.25*
Within Groups	258	3523.33	13.66		257	1455.33	5.66	
Total	266	3756.68			265	1556.99		

*Significant at the 0.05 level.

Table 75. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Terminology Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.94	5.39	7.73
Abstract Line (B & W; Group II)	4.23	7.94	6.71
Abstract Line (Color; Group III)	3.81	7.40	7.22
Detailed, Shaded Drawing (B & W; Group IV)	3.75	7.96	7.79
Detailed, Shaded Drawing (Color; Group V)	3.95	7.88	6.68
Heart Model (B & W; Group VI)	3.67	8.10	8.59
Heart Model (Color; Group VII)	3.19	7.41	6.79
Realistic Photographic (B & W; Group VIII)	3.18	5.91	6.76
Realistic Photographic (Color; Group IX)	4.39	7.62	6.94
Grand Mean		7.25	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 76 were obtained:

Table 76. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	1.69
$\mu I = \mu III$	Group I = Group III	0.84
$\mu I = \mu IV$	Group I = Group IV	0.10
$\mu I = \mu V$	Group I = Group V	1.63
$\mu I = \mu VI$	Group I = Group VI	1.42
$\mu I = \mu VII$	Group I = Group VII	1.53
$\mu I = \mu VIII$	Group I = Group VIII	1.63
$\mu I = \mu IX$	Group I = Group IX	1.29
$\mu II = \mu III$	Group II = Group III	0.84
$\mu II = \mu IV$	Group II = Group IV	1.74
$\mu II = \mu V$	Group II = Group V	0.03
$\mu II = \mu VI$	Group II = Group VI	3.11
$\mu II = \mu VII$	Group II = Group VII	0.13
$\mu II = \mu VIII$	Group II = Group VIII	0.08
$\mu II = \mu IX$	Group II = Group IX	0.37
$\mu III = \mu IV$	Group III = Group IV	0.91
$\mu III = \mu V$	Group III = Group V	0.82
$\mu III = \mu VI$	Group III = Group VI	2.25
$\mu III = \mu VII$	Group III = Group VII	0.69
$\mu III = \mu VIII$	Group III = Group VIII	0.77
$\mu III = \mu IX$	Group III = Group IX	0.45
$\mu IV = \mu V$	Group IV = Group V	1.68
$\mu IV = \mu VI$	Group IV = Group VI	1.29
$\mu IV = \mu VII$	Group IV = Group VII	1.59
$\mu IV = \mu VIII$	Group IV = Group VIII	1.69
$\mu IV = \mu IX$	Group IV = Group IX	1.35
$\mu V = \mu VI$	Group V = Group VI	2.97
$\mu V = \mu VII$	Group V = Group VII	0.15
$\mu V = \mu VIII$	Group V = Group VIII	0.11
$\mu V = \mu IX$	Group V = Group IX	0.39
$\mu VI = \mu VII$	Group VI = Group VII	2.93
$\mu VI = \mu VIII$	Group VI = Group VIII	3.08
$\mu VI = \mu IX$	Group VI = Group IX	2.68
$\mu VII = \mu VIII$	Group VII = Group VIII	0.05
$\mu VII = \mu IX$	Group VII = Group IX	0.24
$\mu VIII = \mu IX$	Group VIII = Group IX	0.30

The Roman numerals are not subscripted because of space limit.

Comparison of the Ninth Grade Treatment Groups on the Delayed Retention Comprehension Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.05 level test (F=2.48). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 77 and 78)

Table 77. Analysis of Variance and Covariance of the Comprehension Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	182.05	22.76	2.27*	8	144.71	18.09	2.48*
Within Groups	258	2590.46	10.04		257	1872.70	7.29	
Total	266	2772.51			265	2017.41		

*Significant at the 0.05 level.

Table 78. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Comprehension Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.40	6.19	7.58
Abstract Line (B & W; Group II)	4.07	8.00	7.28
Abstract Line (Color; Group III)	3.78	5.83	5.73
Detailed, Shaded Drawing (B & W; Group IV)	1.78	5.71	5.61
Detailed, Shaded Drawing (Color; Group V)	3.60	7.12	6.41
Heart Model (B & W; Group VI)	3.65	7.58	7.87
Heart Model (Color; Group VII)	2.38	7.41	7.05
Realistic Photographic (B & W; Group VIII)	3.20	5.91	6.41
Realistic Photographic (Color; Group IX)	2.84	7.28	6.88
Grand Mean		6.78	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 79 were obtained:

Table 79. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
μI = μII	Group I = Group II	0.44
μI = μIII	Group I = Group III	2.68
μI = μIV	Group I = Group IV	2.80
μI = μV	Group I = Group V	1.61
μI = μVI	Group I = Group VI	0.42
μI = μVII	Group I = Group VII	0.76
μI = μVIII	Group I = Group VIII	1.73
μI = μIX	Group I = Group IX	1.00
μII = μIII	Group II = Group III	2.24
μII = μIV	Group II = Group IV	2.37
μII = μV	Group II = Group V	1.20
μII = μVI	Group II = Group VI	0.86
μII = μVII	Group II = Group VII	0.33
μII = μVIII	Group II = Group VIII	1.29
μII = μIX	Group II = Group IX	0.57
μIII = μIV	Group III = Group IV	0.17
μIII = μV	Group III = Group V	0.93
μIII = μVI	Group III = Group VI	3.09
μIII = μVII	Group III = Group VII	1.88
μIII = μVIII	Group III = Group VIII	1.00
μIII = μIX	Group III = Group IX	1.64
μIV = μV	Group IV = Group V	1.08
μIV = μVI	Group IV = Group VI	3.21
μIV = μVII	Group IV = Group VII	2.01
μIV = μVIII	Group IV = Group VIII	1.15
μIV = μIX	Group IV = Group IX	1.78
μV = μVI	Group V = Group VI	2.01
μV = μVII	Group V = Group VII	0.87
μV = μVIII	Group V = Group VIII	0.10
μV = μIX	Group V = Group IX	0.64
μVI = μVII	Group VI = Group VII	1.18
μVI = μVIII	Group VI = Group VIII	2.16
μVI = μIX	Group VI = Group IX	1.42
μVII = μVIII	Group VII = Group VIII	0.93
μVII = μIX	Group VII = Group IX	0.24
μVIII = μIX	Group VIII = Group IX	0.68

The Roman numerals are not subscripted because of space limit.

Comparison of the Tenth Grade Treatment Groups on the Delayed Total Criterion Retention Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=3.27). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 80 and 81)

Table 80. Analysis of Variance and Covariance of the Total Criterion Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	7343.99	918.00	6.27**	8	1074.05	134.26	3.27**
Within Groups	224	32804.50	146.45		223	9154.87	41.05	
Total	232	40148.49			231	10228.92		

**Significant at the 0.01 level.

Table 81. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Total Criterion Test.

Treatment	n	s.d.	Total Mean Test Score Immediate Retention	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	31	8.43	27.77	22.61	30.80
Abstract Line Presentation (B & W; Group II)	21	14.42	46.76	37.38	28.79
Abstract Line Presentation (Color; Group III)	27	16.76	42.19	37.04	29.49
Detailed, Shaded Drawing Presentation (B & W; Group IV)	21	11.43	42.57	37.14	32.26
Detailed, Shaded Drawing Presentation (Color; Group V)	28	11.84	46.86	36.00	27.33
Heart Model Presentation (B & W; Group VI)	22	7.61	30.91	23.05	28.47
Heart Model Presentation (Color; Group VII)	25	10.75	32.36	30.64	34.78
Realistic Photographic Presentation (B & W; Group VIII)	27	14.67	34.26	28.41	30.87
Realistic Photographic Presentation (Color; Group IX)	31	10.38	33.19	24.77	28.18
Grand Mean			37.04	30.05	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 82 were obtained:

Table 82. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	1.11
$\mu I = \mu III$	Group I = Group III	0.78
$\mu I = \mu IV$	Group I = Group IV	0.81
$\mu I = \mu V$	Group I = Group V	2.08
$\mu I = \mu VI$	Group I = Group VI	1.30
$\mu I = \mu VII$	Group I = Group VII	2.31
$\mu I = \mu VIII$	Group I = Group VIII	0.04
$\mu I = \mu IX$	Group I = Group IX	1.61
$\mu II = \mu III$	Group II = Group III	0.38
$\mu II = \mu IV$	Group II = Group IV	1.75
$\mu II = \mu V$	Group II = Group V	0.79
$\mu II = \mu VI$	Group II = Group VI	0.16
$\mu II = \mu VII$	Group II = Group VII	3.16
$\mu II = \mu VIII$	Group II = Group VIII	1.12
$\mu II = \mu IX$	Group II = Group IX	0.34
$\mu III = \mu IV$	Group III = Group IV	1.49
$\mu III = \mu V$	Group III = Group V	1.25
$\mu III = \mu VI$	Group III = Group VI	0.55
$\mu III = \mu VII$	Group III = Group VII	2.97
$\mu III = \mu VIII$	Group III = Group VIII	0.79
$\mu III = \mu IX$	Group III = Group IX	0.78
$\mu IV = \mu V$	Group IV = Group V	2.67
$\mu IV = \mu VI$	Group IV = Group VI	1.94
$\mu IV = \mu VII$	Group IV = Group VII	1.33
$\mu IV = \mu VIII$	Group IV = Group VIII	0.75
$\mu IV = \mu IX$	Group IV = Group IX	2.25
$\mu V = \mu VI$	Group V = Group VI	0.62
$\mu V = \mu VII$	Group V < Group VII	4.23**
$\mu V = \mu VIII$	Group V = Group VIII	2.05
$\mu V = \mu IX$	Group V = Group IX	0.51
$\mu VI = \mu VII$	Group VI = Group VII	3.37
$\mu VI = \mu VIII$	Group VI = Group VIII	1.30
$\mu VI = \mu IX$	Group VI = Group IX	0.16
$\mu VII = \mu VIII$	Group VII = Group VIII	2.20
$\mu VII = \mu IX$	Group VII > Group IX	3.83*
$\mu VIII = \mu IX$	Group VIII = Group IX	1.59

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Tenth Grade Treatment Groups on the Delayed Retention Drawing Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 83 and 84)

Table 83. Analysis of Variance and Covariance of the Drawing Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	810.39	101.30	5.24**	8	138.17	17.27	1.97
Within Groups	224	4333.85	19.35		223	1958.50	8.78	
Total	232	5144.24			231	2096.67		

**Significant at the 0.01 level.

Table 84. Standard Deviations and Adjusted Mean Scores for Each Treatment on the Drawing Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.30	4.84	7.43
Abstract Line (B & W; Group II)	5.00	10.67	7.94
Abstract Line (Color; Group III)	5.15	8.00	6.56
Detailed, Shaded Drawing (B & W; Group IV)	3.75	8.05	6.50
Detailed, Shaded Drawing (Color; Group V)	4.13	10.18	7.43
Heart Model (B & W; Group VI)	4.15	5.68	7.40
Heart Model (Color; Group VII)	3.85	7.68	8.99
Realistic Photographic (B & W; Group VIII)	5.76	7.63	8.41
Realistic Photographic (Color; Group IX)	4.07	5.77	6.85
Grand Mean		7.49	

Comparison of the Tenth Grade Treatment Groups on the Delayed Retention Identification Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=2.73). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 85 and 86)

Table 85. Analysis of Variance and Covariance of the Identification Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	604.69	75.59	4.90**	8	148.21	18.53	2.73**
Within Groups	224	3459.00	15.44		223	1511.32	6.78	
Total	232	4063.69			231	1659.53		

**Significant at the 0.01 level.

Table 86. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Identification Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.89	6.29	8.64
Abstract Line (B & W; Group II)	4.38	10.71	8.25
Abstract Line (Color; Group III)	5.05	9.48	8.18
Detailed, Shaded Drawing (B & W; Group IV)	3.27	11.00	9.60
Detailed, Shaded Drawing (Color; Group V)	3.58	10.39	7.90
Heart Model (B & W; Group VI)	3.50	6.64	8.19
Heart Model (Color; Group VII)	2.50	9.48	10.67
Realistic Photographic (B & W; Group VIII)	5.11	8.52	9.22
Realistic Photographic (Color; Group IX)	4.14	7.81	8.78
Grand Mean		8.81	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 87 were obtained:

Table 87. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	0.53
$\mu I = \mu III$	Group I = Group III	0.67
$\mu I = \mu IV$	Group I = Group IV	1.30
$\mu I = \mu V$	Group I = Group V	1.09
$\mu I = \mu VI$	Group I = Group VI	0.62
$\mu I = \mu VII$	Group I = Group VII	2.90
$\mu I = \mu VIII$	Group I = Group VIII	0.85
$\mu I = \mu IX$	Group I = Group IX	0.21
$\mu II = \mu III$	Group II = Group III	0.09
$\mu II = \mu IV$	Group II = Group IV	1.68
$\mu II = \mu V$	Group II = Group V	0.47
$\mu II = \mu VI$	Group II = Group VI	0.08
$\mu II = \mu VII$	Group II = Group VII	3.14
$\mu II = \mu VIII$	Group II = Group VIII	1.28
$\mu II = \mu IX$	Group II = Group IX	0.72
$\mu III = \mu IV$	Group III = Group IV	1.87
$\mu III = \mu V$	Group III = Group V	0.40
$\mu III = \mu VI$	Group III = Group VI	0.01
$\mu III = \mu VII$	Group III < Group VII	3.45**
$\mu III = \mu VIII$	Group III = Group VIII	1.47
$\mu III = \mu IX$	Group III = Group IX	0.88
$\mu IV = \mu V$	Group IV = Group V	2.26
$\mu IV = \mu VI$	Group IV = Group VI	1.77
$\mu IV = \mu VII$	Group IV = Group VII	1.39
$\mu IV = \mu VIII$	Group IV = Group VIII	0.50
$\mu IV = \mu IX$	Group IV = Group IX	1.11
$\mu V = \mu VI$	Group V = Group VI	0.39
$\mu V = \mu VII$	Group V < Group VII	3.87*
$\mu V = \mu VIII$	Group V = Group VIII	1.88
$\mu V = \mu IX$	Group V = Group IX	1.30
$\mu VI = \mu VII$	Group VI = Group VII	3.26
$\mu VI = \mu VIII$	Group VI = Group VIII	1.38
$\mu VI = \mu IX$	Group VI = Group IX	0.81
$\mu VII = \mu VIII$	Group VII = Group VIII	2.01
$\mu VII = \mu IX$	Group VII = Group IX	2.70
$\mu VIII = \mu IX$	Group VIII = Group IX	0.64

*Significant at the 0.05 level.

**Significant at the 0.01 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Tenth Grade Treatment Groups on the Delayed Retention Terminology Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.05 level test (F=2.57). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 88 and 89)

Table 88. Analysis of Variance and Covariance of the Terminology Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	462.76	57.85	5.31**	8	110.69	13.84	2.57*
Within Groups	224	2438.16	10.89		223	1200.67	5.38	
Total	232	2900.92			231	1311.36		

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 89. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Terminology Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.52	5.94	7.81
Abstract Line (B & W; Group II)	3.75	8.67	6.70
Abstract Line (Color; Group III)	4.76	8.19	7.15
Detailed, Shaded Drawing (B & W; Group IV)	3.87	9.71	8.60
Detailed, Shaded Drawing (Color; Group V)	3.13	8.50	6.52
Heart Model (B & W; Group VI)	1.98	5.14	6.38
Heart Model (Color; Group VII)	3.71	7.04	7.99
Realistic Photographic (B & W; Group VIII)	2.85	6.59	7.16
Realistic Photographic (Color; Group IX)	2.52	5.84	6.62
Grand Mean		7.20	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 90 were obtained:

Table 90. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
μI = μII	Group I = Group II	1.69
μI = μIII	Group I = Group III	1.08
μI = μIV	Group I = Group IV	1.21
μI = μV	Group I = Group V	2.13
μI = μVI	Group I = Group VI	2.21
μI = μVII	Group I = Group VII	0.29
μI = μVIII	Group I = Group VIII	1.06
μI = μIX	Group I = Group IX	2.02
μII = μIII	Group II = Group III	0.67
μII = μIV	Group II = Group IV	2.65
μII = μV	Group II = Group V	0.27
μII = μVI	Group II = Group VI	0.45
μII = μVII	Group II = Group VII	1.88
μII = μVIII	Group II = Group VIII	0.68
μII = μIX	Group II = Group IX	0.12
μIII = μIV	Group III = Group IV	2.15
μIII = μV	Group III = Group V	1.01
μIII = μVI	Group III = Group VI	1.16
μIII = μVII	Group III = Group VII	1.30
μIII = μVIII	Group III = Group VIII	0.02
μIII = μIX	Group III = Group IX	0.87
μIV = μV	Group IV = Group V	3.11
μIV = μVI	Group IV = Group VI	3.14
μIV = μVII	Group IV = Group VII	0.89
μIV = μVIII	Group IV = Group VIII	2.13
μIV = μIX	Group IV = Group IX	3.02
μV = μVI	Group V = Group VI	0.21
μV = μVII	Group V = Group VII	2.30
μV = μVIII	Group V = Group VIII	1.02
μV = μIX	Group V = Group IX	0.17
μVI = μVII	Group VI = Group VII	2.37
μVI = μVIII	Group VI = Group VIII	1.17
μVI = μIX	Group VI = Group IX	0.37
μVII = μVIII	Group VII = Group VIII	1.29
μVII = μIX	Group VII = Group IX	2.20
μVIII = μIX	Group VIII = Group IX	0.88

The Roman numerals are not subscripted because of space limit.

Comparison of the Tenth Grade Treatment Groups on the Delayed Retention Comprehension Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.05 level test (F=2.56). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 91 and 92)

Table 91. Analysis of Variance and Covariance of the Comprehension Test Scores for the Nine Treatment Groups.

Variance	Original Analysis D.F.	Original Analysis Sum of Squares	Original Analysis Mean Square	Original Analysis F	Adjusted Analysis D.F.	Adjusted Analysis Sum of Squares	Adjusted Analysis Mean Square	Adjusted Analysis F
Among Groups	8	322.08	40.26	4.42**	8	127.20	15.90	2.56*
Within Groups	224	2041.81	9.12		223	1386.28	6.22	
Total	232	2363.89			231	1513.48		

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 92. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Comprehension Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.09	5.58	6.95
Abstract Line (B & W; Group II)	4.08	7.67	6.24
Abstract Line (Color: Group III)	3.81	8.30	7.54
Detailed, Shaded Drawing (B & W; Group IV)	3.17	8.86	8.04
Detailed, Shaded Drawing (Color; Group V)	3.13	6.96	5.52
Heart Model (B & W; Group VI)	2.02	5.59	6.49
Heart Model (Color; Group VII)	3.38	6.44	7.13
Realistic Photographic (B & W; Group VIII)	2.63	6.07	6.48
Realistic Photographic (Color; Group IX)	2.55	5.35	5.92
Grand Mean		6.67	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 93 were obtained:

Table 93. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu\mathrm{I} = \mu\mathrm{II}$	Group I = Group II	1.01
$\mu\mathrm{I} = \mu\mathrm{III}$	Group I = Group III	0.90
$\mu\mathrm{I} = \mu\mathrm{IV}$	Group I = Group IV	1.55
$\mu\mathrm{I} = \mu\mathrm{V}$	Group I = Group V	2.20
$\mu\mathrm{I} = \mu\mathrm{VI}$	Group I = Group VI	0.66
$\mu\mathrm{I} = \mu\mathrm{VII}$	Group I = Group VII	0.27
$\mu\mathrm{I} = \mu\mathrm{VIII}$	Group I = Group VIII	0.72
$\mu\mathrm{I} = \mu\mathrm{IX}$	Group I = Group IX	1.63
$\mu\mathrm{II} = \mu\mathrm{III}$	Group II = Group III	1.79
$\mu\mathrm{II} = \mu\mathrm{IV}$	Group II = Group IV	2.34
$\mu\mathrm{II} = \mu\mathrm{V}$	Group II = Group V	1.00
$\mu\mathrm{II} = \mu\mathrm{VI}$	Group II = Group VI	0.33
$\mu\mathrm{II} = \mu\mathrm{VII}$	Group II = Group VII	1.21
$\mu\mathrm{II} = \mu\mathrm{VIII}$	Group II = Group VIII	0.33
$\mu\mathrm{II} = \mu\mathrm{IX}$	Group II = Group IX	0.45
$\mu\mathrm{III} = \mu\mathrm{IV}$	Group III = Group IV	0.69
$\mu\mathrm{III} = \mu\mathrm{V}$	Group III = Group V	3.00
$\mu\mathrm{III} = \mu\mathrm{VI}$	Group III = Group VI	1.47
$\mu\mathrm{III} = \mu\mathrm{VII}$	Group III = Group VII	0.59
$\mu\mathrm{III} = \mu\mathrm{VIII}$	Group III = Group VIII	1.56
$\mu\mathrm{III} = \mu\mathrm{IX}$	Group III = Group IX	2.47
$\mu\mathrm{IV} = \mu\mathrm{V}$	Group IV < Group V	3.50*
$\mu\mathrm{IV} = \mu\mathrm{VI}$	Group IV = Group VI	2.04
$\mu\mathrm{IV} = \mu\mathrm{VII}$	Group IV = Group VII	1.23
$\mu\mathrm{IV} = \mu\mathrm{VIII}$	Group IV = Group VIII	2.15
$\mu\mathrm{IV} = \mu\mathrm{IX}$	Group IV = Group IX	3.01
$\mu\mathrm{V} = \mu\mathrm{VI}$	Group V = Group VI	1.37
$\mu\mathrm{V} = \mu\mathrm{VII}$	Group V = Group VII	2.35
$\mu\mathrm{V} = \mu\mathrm{VIII}$	Group V = Group VIII	1.43
$\mu\mathrm{V} = \mu\mathrm{IX}$	Group V = Group IX	0.62
$\mu\mathrm{VI} = \mu\mathrm{VII}$	Group VI = Group VII	0.88
$\mu\mathrm{VI} = \mu\mathrm{VIII}$	Group VI = Group VIII	0.04
$\mu\mathrm{VI} = \mu\mathrm{IX}$	Group VI = Group IX	0.82
$\mu\mathrm{VII} = \mu\mathrm{VIII}$	Group VII = Group VIII	0.94
$\mu\mathrm{VII} = \mu\mathrm{IX}$	Group VII = Group IX	1.80
$\mu\mathrm{VIII} = \mu\mathrm{IX}$	Group VIII = Group IX	0.85

*Significant at the 0.05 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Eleventh Grade Treatment Groups on the Delayed Total Criterion Retention Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 94 and 95)

Table 94. Analysis of Variance and Covariance of the Total Criterion Test Scores for the Nine Treatment Groups.

Variance	Original Analysis D.F.	Original Analysis Sum of Squares	Original Analysis Mean Square	Original Analysis F	Adjusted Analysis D.F.	Adjusted Analysis Sum of Squares	Adjusted Analysis Mean Square	Adjusted Analysis F
Among Groups	8	3694.91	461.86	2.84**	8	477.08	59.64	1.29
Within Groups	242	39334.21	162.54		241	11150.68	46.27	
Total	250	43029.12			249	11627.76		

**Significant at the 0.01 level.

Table 95. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Total Criterion Test.

Treatment	n	s.d.	Total Mean Test Score Immediate Retention	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	31	8.40	24.97	21.81	30.51
Abstract Line Presentation (B & W; Group II)	30	15.33	39.33	31.00	27.37
Abstract Line Presentation (Color; Group III)	23	8.23	36.83	30.17	28.70
Detailed, Shaded Drawing Presentation (B & W; Group IV)	28	12.65	36.46	31.39	30.23
Detailed, Shaded Drawing Presentation (Color; Group V)	32	14.46	41.69	33.63	27.98
Heart Model Presentation (B & W; Group VI)	28	11.65	31.75	26.07	28.95
Heart Model Presentation (Color; Group VII)	21	13.40	35.52	27.43	27.07
Realistic Photographic Presentation (B & W; Group VIII)	33	16.13	37.67	29.15	26.96
Realistic Photographic Presentation (Color; Group IX)	25	10.27	31.12	22.88	26.30
Grand Mean			35.11	28.27	

Comparison of the Eleventh Grade Treatment Groups on the Delayed Retention Drawing Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 96 and 97)

Table 96. Analysis of Variance and Covariance of the Drawing Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	331.93	41.49	2.08*	8	106.76	13.34	1.60
Within Groups	242	4840.10	20.00		241	2013.89	8.36	
Total	250	5172.03			249	2120.65		

*Significant at the 0.05 level.

Table 97. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Drawing Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.77	5.13	7.88
Abstract Line (B & W; Group II)	5.77	7.70	6.55
Abstract Line (Color; Group III)	3.62	8.13	7.66
Detailed, Shaded Drawing (B & W; Group IV)	3.71	7.00	6.63
Detailed, Shaded Drawing (Color; Group V)	5.31	8.53	6.74
Heart Model (B & W; Group VI)	4.01	5.82	6.73
Heart Model (Color; Group VII)	4.65	5.76	5.65
Realistic Photographic (B & W; Group VIII)	5.14	6.58	5.88
Realistic Photographic (Color; Group IX)	4.07	5.64	6.73
Grand Mean		6.73	

Comparison of the Eleventh Grade Treatment Groups on the Delayed Retention Identification Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$ (See Tables 98 and 99)

Table 98. Analysis of Variance and Covariance of the Identification Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	414.53	51.82	3.52**	8	117.13	14.64	1.85
Within Groups	242	3566.16	14.74		241	1903.40	7.90	
Total	250	3980.69			249	2020.53		

**Significant at the 0.01 level.

Table 99. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Identification Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.51	5.61	7.73
Abstract Line (B & W; Group II)	4.24	8.57	7.69
Abstract Line (Color; Group III)	3.55	9.52	9.16
Detailed, Shaded Drawing (B & W; Group IV)	4.86	9.18	8.90
Detailed, Shaded Drawing (Color; Group V)	4.33	8.94	7.55
Heart Model (B & W; Group VI)	2.98	6.86	7.57
Heart Model (Color; Group VII)	2.83	7.33	7.25
Realistic Photographic (B & W; Group VIII)	4.07	7.55	7.01
Realistic Photographic (Color; Group IX)	3.22	6.32	7.15
Grand Mean		7.75	

Comparison of the Eleventh Grade Treatment Groups on the Delayed Retention Terminology Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.05 level test (F=2.15). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 100 and 101)

Table 100. Analysis of Variance and Covariance of the Terminology Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	288.47	36.06	2.35*	8	116.93	14.62	2.15*
Within Groups	242	3718.78	15.37		241	1642.21	6.81	
Total	250	4007.25			249	1759.14		

*Significant at the 0.05 level.

Table 101. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Terminology Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.26	5.35	7.72
Abstract Line (B & W; Group II)	3.93	6.83	5.85
Abstract Line (Color; Group III)	2.83	6.78	6.38
Detailed, Shaded Drawing (B & W; Group IV)	3.80	8.21	7.90
Detailed, Shaded Drawing (Color; Group V)	4.59	6.66	7.12
Heart Model (B & W; Group VI)	4.33	7.15	7.92
Heart Model (Color; Group VII)	4.14	7.33	7.24
Realistic Photographic (B & W; Group VIII)	4.97	7.67	7.07
Realistic Photographic (Color; Group IX)	1.98	5.48	6.41
Grand Mean		7.08	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 102 were obtained:

Table 102. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	2.80
$\mu I = \mu III$	Group I = Group III	1.87
$\mu I = \mu IV$	Group I = Group IV	0.26
$\mu I = \mu V$	Group I = Group V	0.91
$\mu I = \mu VI$	Group I = Group VI	0.29
$\mu I = \mu VII$	Group I = Group VII	0.65
$\mu I = \mu VIII$	Group I = Group VIII	1.00
$\mu I = \mu IX$	Group I = Group IX	1.87
$\mu II = \mu III$	Group II = Group III	0.73
$\mu II = \mu IV$	Group II = Group IV	2.99
$\mu II = \mu V$	Group II = Group V	1.92
$\mu II = \mu VI$	Group II = Group VI	3.02
$\mu II = \mu VII$	Group II = Group VII	1.87
$\mu II = \mu VIII$	Group II = Group VIII	1.85
$\mu II = \mu IX$	Group II = Group IX	0.79
$\mu III = \mu IV$	Group III = Group IV	2.07
$\mu III = \mu V$	Group III = Group V	1.04
$\mu III = \mu VI$	Group III = Group VI	2.10
$\mu III = \mu VII$	Group III = Group VII	1.09
$\mu III = \mu VIII$	Group III = Group VIII	0.97
$\mu III = \mu IX$	Group III = Group IX	0.04
$\mu IV = \mu V$	Group IV = Group V	1.16
$\mu IV = \mu VI$	Group IV = Group VI	0.03
$\mu IV = \mu VII$	Group IV = Group VII	0.88
$\mu IV = \mu VIII$	Group IV = Group VIII	1.24
$\mu IV = \mu IX$	Group IV = Group IX	2.08
$\mu V = \mu VI$	Group V = Group VI	1.18
$\mu V = \mu VII$	Group V = Group VII	0.16
$\mu V = \mu VIII$	Group V = Group VIII	0.08
$\mu V = \mu IX$	Group V = Group IX	1.02
$\mu VI = \mu VII$	Group VI = Group VII	0.90
$\mu VI = \mu VIII$	Group VI = Group VIII	1.27
$\mu VI = \mu IX$	Group VI = Group IX	2.10
$\mu VII = \mu VIII$	Group VII = Group VIII	0.23
$\mu VII = \mu IX$	Group VII = Group IX	1.07
$\mu VIII = \mu IX$	Group VIII = Group IX	0.95

The Roman numerals are not subscripted because of space limit.

Comparison of the Eleventh Grade Treatment Groups on the Delayed Retention Comprehension Test

The F-ratio does not exceed the critical value for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 103 and 104)

Table 103. Analysis of Variance and Covariance of the Comprehension Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	150.66	18.83	1.88	8	34.37	4.30	.62
Within Groups	242	2421.23	10.01		241	1660.56	6.89	
Total	250	2571.89			249			

Table 104. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Comprehension Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	2.09	5.61	7.04
Abstract Line (B & W; Group II)	3.88	7.60	7.00
Abstract Line (Color; Group III)	2.35	6.17	5.93
Detailed, Shaded Drawing (B & W; Group IV)	3.02	6.93	6.74
Detailed, Shaded Drawing (Color: Group V)	3.05	7.59	6.66
Heart Model (B & W; Group VI)	2.87	6.29	6.76
Heart Model (Color; Group VII)	4.02	6.62	6.56
Realistic Photographic (B & W; Group VIII)	3.88	7.30	6.94
Realistic Photographic (Color; Group IX)	2.68	5.44	6.00
Grand Mean		6.67	

Comparison of the Twelfth Grade Treatment Groups on the Delayed Retention Total Criterion Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypotheses cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 105 and 106)

Table 105. Analysis of Variance and Covariance of the Total Criterion Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	4291.88	536.48	2.77**	8	341.27	42.66	.73
Within Groups	238	46054.77	193.51		237	13924.13	58.75	
Total	246	50346.65			245	14265.40		

**Significant at the 0.01 level.

Table 106. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Total Criterion Test.

Treatment	n	s.d.	Total Mean Test Score Immediate Retention	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	18	14.24	37.11	32.56	40.14
Abstract Line Presentation (B & W; Group II)	27	17.05	43.89	36.22	37.81
Abstract Line Presentation (Color; Group III)	28	7.84	43.82	36.96	38.62
Detailed, Shaded Drawing Presentation (B & W; Group IV)	36	17.07	47.31	40.17	38.74
Detailed, Shaded Drawing Presentation (Color; Group V)	29	8.65	56.03	46.62	37.47
Heart Model Presentation (B & W; Group VI)	34	13.87	45.21	36.41	37.84
Heart Model Presentation (Color; Group VII)	30	12.02	43.27	33.63	35.78
Realistic Photographic Presentation (B & W; Group VIII)	28	14.97	42.61	33.86	36.58
Realistic Photographic Presentation (Color; Group IX)	17	17.33	49.94	41.53	37.77
Grand Mean			45.68	37.64	

Comparison of the Twelfth Grade Treatment Groups on the Delayed Retention Drawing Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 107 and 108)

Table 107. Analysis of Variance and Covariance of the Drawing Test Scores for the Nine Treatment Groups.

Variance	Original Analysis				Adjusted Analysis			
	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	257.19	32.15	1.50	8	69.09	8.64	.81
Within Groups	238	5107.49	21.46		237	2533.69	10.69	
Total	246	5364.68			245	2602.78		

Table 108. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Drawing Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	4.67	8.44	10.59
Abstract Line (B & W; Group II)	5.65	8.55	8.90
Abstract Line (Color; Group III)	3.56	9.57	10.04
Detailed, Shaded Drawing (B & W; Group IV)	5.32	10.19	9.79
Detailed, Shaded Drawing (Color; Group V)	4.20	11.41	8.83
Heart Model (B & W; Group VI)	4.14	9.26	9.39
Heart Model (Color; Group VII)	3.37	8.20	8.81
Realistic Photographic (B & W; Group VIII)	4.86	8.54	9.31
Realistic Photographic (Color; Group IX)	5.86	10.18	9.11
Grand Mean		9.39	

Comparison of the Twelfth Grade Treatment Groups on the Delayed Retention Identification Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Talbes 109 and 110)

Table 109. Analysis of Variance and Covariance of the Identification Test Scores for the Nine Treatment Groups.

Variance	Original Analysis D.F.	Original Analysis Sum of Squares	Original Analysis Mean Square	Original Analysis F	Adjusted Analysis D.F.	Adjusted Analysis Sum of Squares	Adjusted Analysis Mean Square	Adjusted Analysis F
Among Groups	8	105.08	18.76	1.05	8	27.40	3.43	.37
Within Groups	238	4244.89	17.84		237	2200.60	9.29	
Total	246	4394.97			245	2228.00		

Table 110. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Identification Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	4.26	8.50	10.41
Abstract Line (B & W; Group II)	5.00	9.70	10.11
Abstract Line (Color; Group III)	3.61	9.61	10.02
Detailed, Shaded Drawing (B & W; Group IV)	4.86	10.33	9.97
Detailed, Shaded Drawing (Color; Group V)	3.57	11.38	9.07
Heart Model (B & W; Group VI)	4.14	9.74	9.84
Heart Model (Color; Group VII)	3.84	9.40	9.94
Realistic Photographic (B & W; Group VIII)	4.18	9.46	10.15
Realistic Photographic (Color; Group IX)	4.23	11.18	10.22
Grand Mean		9.94	

Comparison of the Twelfth Grade Treatment Groups on the Delayed Retention Terminology Test

The test on the effect of the nine treatment groups, via covariance, exceeded the critical value of a 0.01 level test (F=3.31). The F-ratio provides a test of the null hypothesis after the criterion data have been adjusted for the linear trend on the covariate. Hence, the data contradict the general null hypothesis:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 111 and 112)

Table 111. Analysis of Variance and Covariance of the Terminology Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	798.76	99.84	5.32**	8	179.32	22.42	3.31**
Within Groups	238	4470.66	18.78		237	1605.33	6.77	
Total	246	5269.42			245	1784.65		

**Significant at the 0.01 level.

Table 112. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Terminology Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	4.10	8.78	11.04
Abstract Line (B & W; Group II)	4.71	10.19	10.66
Abstract Line (Color; Group III)	3.42	8.32	8.81
Detailed, Shaded Drawing (B & W; Group IV)	5.29	10.58	10.71
Detailed, Shaded Drawing (Color; Group V)	3.33	14.21	11.47
Heart Model (B & W; Group VI)	4.20	9.18	9.30
Heart Model (Color; Group VII)	3.84	8.40	9.04
Realistic Photographic (B & W; Group VIII)	4.56	8.75	9.56
Realistic Photographic (Color; Group IX)	5.19	11.18	10.05
Grand Mean		9.95	

When the adjusted means of the nine treatment groups were considered in terms of Dunn's c-procedure, the values shown in Table 113 were obtained:

Table 113. Analysis of Adjusted Mean Scores for Each Treatment Group.

Null Hypotheses	Statistical Results	c
$\mu I = \mu II$	Group I = Group II	0.48
$\mu I = \mu III$	Group I = Group III	2.84
$\mu I = \mu IV$	Group I = Group IV	0.44
$\mu I = \mu V$	Group I = Group V	0.55
$\mu I = \mu VI$	Group I = Group VI	2.29
$\mu I = \mu VII$	Group I = Group VII	2.58
$\mu I = \mu VIII$	Group I = Group VIII	1.88
$\mu I = \mu IX$	Group I = Group IX	1.13
$\mu II = \mu III$	Group II = Group III	2.64
$\mu II = \mu IV$	Group II = Group IV	0.08
$\mu II = \mu V$	Group II = Group V	1.16
$\mu II = \mu VI$	Group II = Group VI	2.03
$\mu II = \mu VII$	Group II = Group VII	2.35
$\mu II = \mu VIII$	Group II = Group VIII	1.57
$\mu II = \mu IX$	Group II = Group IX	0.76
$\mu III = \mu IV$	Group III = Group IV	2.90
$\mu III = \mu V$	Group III < Group V	3.86*
$\mu III = \mu VI$	Group III = Group VI	0.74
$\mu III = \mu VII$	Group III = Group VII	0.34
$\mu III = \mu VIII$	Group III = Group VIII	1.08
$\mu III = \mu IX$	Group III = Group IX	1.55
$\mu IV = \mu V$	Group IV = Group V	1.17
$\mu IV = \mu VI$	Group IV = Group VI	2.27
$\mu IV = \mu VII$	Group IV = Group VII	2.60
$\mu IV = \mu VIII$	Group IV = Group VIII	1.75
$\mu IV = \mu IX$	Group IV = Group IX	0.86
$\mu V = \mu VI$	Group V > Group VI	3.30*
$\mu V = \mu VII$	Group V > Group VII	3.59*
$\mu V = \mu VIII$	Group V = Group VIII	2.77
$\mu V = \mu IX$	Group V = Group IX	1.79
$\mu VI = \mu VII$	Group VI = Group VII	0.40
$\mu VI = \mu VIII$	Group VI = Group VIII	0.39
$\mu VI = \mu IX$	Group VI = Group IX	0.97
$\mu VII = \mu VIII$	Group VII = Group VIII	0.76
$\mu VII = \mu IX$	Group VII = Group IX	1.28
$\mu VIII = \mu IX$	Group VIII = Group IX	0.61

*Significant at the 0.05 level.

The Roman numerals are not subscripted because of space limit.

Comparison of the Twelfth Grade Treatment Groups on the Delayed Retention Comprehension Test

The F-ratio does not exceed the critical value required for a 0.05 level test. Thus the null hypothesis cannot be rejected. Further analysis among the various group means was not justified:

$H_o:\mu_I=\mu_{II}=\mu_{III}=\mu_{IV}=\mu_V=\mu_{VI}=\mu_{VII}=\mu_{VIII}=\mu_{IX}$ (See Tables 114 and 115)

Table 114. Analysis of Variance and Covariance of the Comprehension Test Scores for the Nine Treatment Groups.

	Original Analysis				Adjusted Analysis			
Variance	D.F.	Sum of Squares	Mean Square	F	D.F.	Sum of Squares	Mean Square	F
Among Groups	8	241.10	30.14	2.62**	8	78.30	9.79	1.29
Within Groups	238	2733.55	11.49		237	1799.01	7.59	
Total	246	2974.65			245	1877.31		

**Significant at the 0.01 level.

Table 115. Standard Deviations and Adjusted Mean Scores for Each Treatment Group on the Comprehension Test.

Treatment	s.d.	Total Mean Test Score Original	Mean Test Score Adjusted
Oral Presentation (Group I)	3.11	6.83	8.13
Abstract Line (B & W; Group II)	3.93	8.00	8.27
Abstract Line (Color; Group III)	2.46	9.46	9.75
Detailed, Shaded Drawing (B & W; Group IV)	3.72	8.83	8.59
Detailed, Shaded Drawing (Color; Group V)	3.29	10.10	8.54
Heart Model (B & W; Group VI)	3.72	8.41	8.48
Heart Model (Color; Group VII)	2.83	7.70	8.07
Realistic Photographic (B & W; Group VIII)	2.57	7.07	7.54
Realistic Photographic (Color; Group IX)	3.39	9.00	8.36
Grand Mean		8.43	

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Statement of the Problem

The purpose of this study was to contribute to the understanding of the conditions which will increase the probability that the desired kinds and degrees of learning will occur with specified visual illustrations. The study compared the relative effectiveness of 8 types of visual illustrations used in complementing oral instruction. It also attempted to determine which illustrated presentations contributed most highly to the facilitation of specific learning objectives: knowledge of location, transfer of learning, knowledge of terminology, and comprehension.

This study also attempted to verify the hypothesis that there does exist in reality a visual continuum representing learning effectiveness which differs substantially from the visual continuum based on existing realism theories which contend that the higher the degree of similarity between an object or situation and a visual, the easier it will be for the student to learn from it. It investigates the possibility of editing reality for instructional effectiveness.

No study of the same nature was found in the available literature. However, several studies were located wherein the results contested the use of the logical realism continuum as the continuum representing learning effectiveness. These studies seem to indicate that increasing abstractness does not mean increased difficulty on the part of the student in learning specific content. Previous research seems to indicate that there may be in existence a totally different continuum--a visual learning continuum--which would be more useful in predicting the effectiveness of various pictorial illustrations in specific learning situations.

The findings outlined in this study indicate that there were significant differences in achievement by students comprising the nine treatment groups, and also that there were significant differences between groups in relation to the specific objectives measured on the immediate and delayed retention criterion tests.

Statement of Hypotheses

Specifically, the following null hypotheses were tested:

(H_1) There are no differences on the total criterion test in immediate retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

H_o: $\mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$

(H_2) There are no differences on the four individual criterion tests in immediate retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

H_o: $\mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$

(H_3) There are no differences on the four individual criterion tests in immediate retention among students receiving black and white illustrations and those receiving colored illustrations in complementing their oral instruction.

H_o: $\mu_{II} = \mu_{III}$; H_o: $\mu_{IV} = \mu_V$; H_o: $\mu_{VI} = \mu_{VII}$; H_o: $\mu_{VIII} = \mu_{IX}$

(H_4) There are no differences on the total criterion test in delayed retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

H_o: $\mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$

(H_5) There are no differences on the four individual criterion tests in delayed retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

H_o: $\mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$

(H_6) There are no differences on the four individual criterion tests in delayed retention among students receiving black and white illustrations and those receiving colored illustrations in complementing their oral instruction.

H_o: $\mu_{II} = \mu_{III}$; H_o: $\mu_{IV} = \mu_V$; H_o: $\mu_{VI} = \mu_{VII}$; H_o: $\mu_{VIII} = \mu_{IX}$

(H_7) There are no significant differences in the relative effectiveness of the various types of visual illustrations used to complement oral instruction among the grade levels participating in the study--ninth, tenth, eleventh, and twelfth.

Method of Procedure

The experimental population for this study consisted of 1,054 ninth, tenth, eleventh, and twelfth grade students from the Sullivan County High School, Laporte, Pennsylvania, and the Farrell School District, Farrell, Pennsylvania. Classes of students were randomly assigned to one of the nine treatment groups.

The experiment was administered in order that the students in each treatment group would be pretested, witness the presentation, and then undergo four individual posttests. Each treatment group received a delayed retention test two weeks after the initial testing session. Scores on the criterion tests were analyzed in terms of the analysis of covariance technique for scores on both the immediate and delayed retention tests. Comparison among the several means was effected via Dunn's c-procedure.

Summary of Ninth Grade Analyses:
Immediate Retention

A. On the total criterion test (see Tables 5 and 6), the various slide sequences facilitated total student learning with differing degrees of effectiveness. In relation to the promotion of student achievement on the total criterion test, the test results indicated the following (see Table 7):

1. The abstract line presentation (b & w), the detailed, shaded drawing presentation (b & w), the heart model presentation (color), and the realistic photographic presentation (color) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the abstract line presentation (color), detailed, shaded drawing presentation (color), heart model presentation (b & w), and the realistic photographic presentation (b & w).

3. The abstract line presentation (color) and the detailed, shaded drawing presentation (color) were both more effective than the realistic photographic presentation (b & w).

4. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness no significant differences were found.

B. In relation to the promotion of student achievement on the drawing test, the test results indicated the following (see Table 10):

1. The abstract line presentations (b & w and color), the detailed, shaded drawing presentations (b & w and color), and the heart model presentation (color) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the heart model presentation (b & w), and the realistic photographic presentations (b & w and color).

3. The abstract line presentation (b & w) and the heart model presentation (color) were both more effective than the heart model presentation (b & w).

4. The heart model presentation (color) was more effective than the heart model presentation (b & w).

C. In relation to the promotion of student achievement on the identification test, the test results indicated the following (see Table 13):

1. The oral presentation alone was as effective as each of the visual presentations.

2. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

D. In relation to the promotion of student achievement on the terminology test, the test results indicated the following (see Table 16):

1. The oral presentation alone was found to be equally as effective as the abstract line presentations (b & w and color), the heart model presentations (b & w and color), and the realistic photographic presentations (b & w and color).

2. The detailed, shaded drawing presentations (b & w and color) were both more effective than the oral presentation alone.

3. The detailed, shaded drawing presentation (color) was more effective than the abstract line presentation (color).

4. The detailed, shaded drawing presentation (color) was more effective than the realistic photographic presentation (b & w).

5. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

E. In relation to the promotion of student achievement on the comprehension test, the test results indicated the following (see Table 19):

1. The oral presentation alone was as effective as each of the visual presentations.

2. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

Summary of Tenth Grade Analyses: Immediate Retention

A. On the total criterion test (see Tables 20 and 21), the various slide sequences facilitated total student learning with differing degrees of effectiveness. In relation to the promotion of student achievement on the total criterion test, the test results indicated the following (see Table 22):

1. The abstract line presentations (b & w and color) and the detailed, shaded drawing presentation (color) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color), and the realistic photographic presentations (b & w and color).

3. The abstract line presentation (b & w) was more effective than the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color) and the realistic photographic presentations (b & w and color).

4. The abstract line presentation (color) was more effective than the heart model presentation (b & w).

5. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color) and the realistic photographic presentations (b & w and color).

6. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w).

B. In relation to the promotion of student achievement on the drawing test, the test results indicated the following (see Table 25):

1. The abstract line presentations (b & w and color), the detailed, shaded drawing presentation (color), the heart model presentation (color), and the realistic photographic presentation (b & w) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the detailed, shaded drawing presentation (b & w), the heart model presentation (b & w), and the realistic photographic presentation (color).

3. The abstract line presentation (b & w) was more effective than the abstract line presentation (color), the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color), and the realistic photographic presentations (b & w and color).

4. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w), the heart model presentation (b & w) and the realistic photographic presentation (color).

5. The abstract line presentation (b & w) was more effective than the abstract line presentation (color).

6. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w).

C. In relation to the promotion of student achievement on the identification test, the test results indicated the following (see Table 28):

1. The abstract line presentation (b & w), the detailed, shaded drawing presentation (color), and the heart model presentation were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the abstract line presentation (color), the detailed, shaded drawing presentation (b & w), the heart model presentation (b & w), and the realistic photographic presentations (b & w and color).

3. The detailed, shaded drawing presentation (color) was more effective than the realistic photographic presentation (color).

4. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

D. In relation to the promotion of student achievement on the terminology test, the test results indicated the following (see Table 31):

1. The abstract line presentation (color) and the detailed, shaded drawing presentation (color) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the abstract line presentation (b & w), the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color), and the realistic photographic presentations (b & w and color).

3. The abstract line presentation (color) was more effective than the realistic photographic presentations (b & w and color).

4. The detailed, shaded drawing presentation (color) was more effective than the heart model presentation (color) and the realistic photographic presentations (b & w and color).

5. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

E. In relation to the promotion of student achievement on the comprehension test, the test results indicated the following (see Table 34):

1. The detailed, shaded drawing presentation (color) was more effective than the oral presentation alone.

2. The oral presentation alone was more effective than the heart model presentation (b & w) and the realistic photographic presentation (b & w).

3. The oral presentation alone was as effective as the abstract line presentations (b & w and color), the detailed, shaded drawing presentation (b & w), the heart model presentation (color), and the realistic photographic presentation (color).

4. The abstract line presentation (b & w) was more effective than the detailed, shaded drawing presentation (b & w), and the heart model presentations (b & w and color).

5. The abstract line presentation (color) was more effective than the detailed, shaded drawing presentation (b & w) and the heart model presentations (b & w and color).

6. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color), and the realistic photographic presentation (color).

7. The realistic photographic presentation (b & w) was more effective than the detailed, shaded drawing presentation (b & w) and the heart model presentations (b & w and color).

8. The realistic photographic presentation (color) was more effective than the heart model presentations (b & w and color).

9. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w).

Summary of Eleventh Grade Analyses: Immediate Retention

A. On the total criterion test (see Tables 35 and 36), the various slide sequences facilitated total student learning with differing degrees of effectiveness. In relation to the promotion of student achievement on the total criterion test, the test results indicated the following (see Table 37):

1. The abstract line presentations (b & w and color), the detailed, shaded drawing presentation (color), and the realistic photographic presentation (b & w) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color), and the realistic photographic presentation (color).

3. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

B. In relation to the promotion of student achievement on the drawing test, the test results indicated the following (see Table 40):

1. The abstract line presentations (b & w and color) and the detailed, shaded drawing presentation (color) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color) and the realistic photographic presentations (b & w and color).

3. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

C. In relation to the promotion of student achievement on the identification test, the test results indicated the following (see Table 43):

1. The abstract line presentation (b & w), the detailed, shaded drawing presentation (color), and the realistic photographic presentation (b & w) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the abstract line presentation (color), the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color) and the realistic photographic presentation (color).

3. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w) and the heart model presentations (b & w and color).

4. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w).

D. In relation to the promotion of student achievement on the terminology test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 44 and 45). Further analysis among the various group means was not justified.

E. In relation to the promotion of student achievement on the comprehension test, the test results indicated the following (see Table 48):

1. The oral presentation alone was as effective as each of the visual presentations.

2. The abstract line presentations (b & w and color), the detailed, shaded drawing presentations (b & w and color), and the realistic photographic presentation (b & w) were more effective than the realistic photographic presentation (color).

3. The realistic photographic presentation (b & w) was more effective than the realistic photographic presentation (color).

Summary of Twelfth Grade Analyses: Immediate Retention

A. On the total criterion test (see Tables 49 and 50), the various slide sequences facilitated total student learning with differing degrees of effectiveness. In relation to the promotion of student achievement on the total criterion test, the test results indicated the following (see Table 51):

1. The detailed, shaded drawing presentation (color) was more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the abstract line presentations (b & w and color), the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color) and the realistic photographic presentations (b & w and color).

3. The detailed, shaded drawing presentation (color) was more effective than each of the other treatment presentations.

4. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w).

B. In relation to the promotion of student achievement on the drawing test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 52 and 53). Further analysis among the various group means was not justified.

C. In relation to the promotion of student achievement on the identification test, the test results indicated the following (see Table 56):

1. The detailed, shaded drawing presentation (color) was more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the abstract line presentations (b & w and color), the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color), and the realistic photographic presentations (b & w and color).

3. The detailed, shaded drawing presentation (color) was more effective than the abstract line presentations (b & w and color) and the realistic photographic presentation (b & w).

4. The detailed, shaded drawing presentation (b & w) and the heart model presentation (b & w) were more effective than the abstract line presentation (color).

5. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

D. In relation to the promotion of student achievement on the terminology test, the test results indicated the following (see Table 59):

1. The oral presentation alone was as effective as the abstract line presentations (b & w and color), the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color), and the realistic photographic presentations (b & w and color).

2. The detailed, shaded drawing presentation (color) was more effective than each of the other treatment groups.

E. In relation to the promotion of student achievement on the comprehension test, the test results indicated the following (see Table 62):

1. The oral presentation alone was as effective as the abstract line presentations (b & w and color), the detailed, shaded drawing presentation (b & w), the heart model presentations (b & w and color), and the realistic photographic presentations (b & w and color).

2. The detailed, shaded drawing presentation (color) was more effective than each of the other treatment groups.

Summary of Ninth Grade Analyses: Delayed Retention

A. In relation to the promotion of student achievement on the total criterion test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 67 and 68). Further analysis among the various group means was not justified.

B. In relation to the promotion of student achievement on the drawing test, the test results indicated the following (see Table 71):

1. The abstract line presentations (b & w and color) were more effective than the oral presentation alone.

2. The oral presentation alone was as effective as the detailed, shaded drawing presentations (b & w and color), the heart model presentations (b & w and color), and the realistic photographic presentations (b & w and color).

3. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

C. In relation to the promotion of student achievement on the identification test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 72 and 73). Further analysis among the various group means was not justified.

D. In relation to the promotion of student achievement on the terminology test, the test results indicated the following (see Table 76):

1. The oral presentation alone was as effective as each of the visual presentations.

2. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

E. In relation to the promotion of student achievement on the comprehension test, the test results indicated the following (see Table 79):

1. The oral presentation alone was as effective as each of the visual presentations.

2. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

Summary of Tenth Grade Analyses: Delayed Retention

A. In relation to the promotion of student achievement on the total criterion test, the test results indicated the following (see Table 82):

1. The oral presentation alone was as effective as each of the visual presentations.

2. The detailed, shaded drawing presentation (color) and the realistic photographic presentation (color) were more effective than the heart model presentation (color).

3. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

B. In relation to the promotion of student achievement on the drawing test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 83 and 84). Further analysis among the various group means was not justified.

C. In relation to the promotion of student achievement on the identification test, the test results indicated the following (see Table 87):

1. The oral presentation alone was as effective as each of the visual presentations.

2. The heart model presentation (color) was more effective than the abstract line presentation (color) and the detailed, shaded drawing presentation (color).

3. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

D. In relation to the promotion of student achievement on the terminology test, the test results indicated the following (see Table 90):

1. The oral presentation alone was as effective as each of the visual presentations.

2. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

E. In relation to the promotion of student achievement on the comprehension test, the test results indicated the following (see Table 93):

1. The oral presentation alone was as effective as each of the visual presentations.

2. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w).

Summary of Eleventh Grade Analyses: Delayed Retention

A. In relation to the promotion of student achievement on the total criterion test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 94 and 95). Further analysis among the various group means was not justified.

B. In relation to the promotion of student achievement on the drawing test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 96 and 97). Further analysis among the various group means was not justified.

C. In relation to the promotion of student achievement on the drawing test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 98 and 99). Further analysis among the various group means was not justified.

D. In relation to the promotion of student achievement on the terminology test, the test results indicated the following (see Table 102):

1. The oral presentation alone was as effective as each of the visual presentations.

2. When the black and white and color versions of each visual presentation were compared in terms of their instructional effectiveness, no significant differences were found.

E. In relation to the promotion of student achievement on the comprehension test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 103 and 104). Further analysis among the various group means was not justified.

Summary of Twelfth Grade Analyses: Delayed Retention

A. In relation to the promotion of student achievement on the total criterion test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 105 and 106). Further analysis among the various group means was not justified.

B. In relation to the promotion of student achievement on the drawing test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 107 and 108). Further analysis among the various group means was not justified.

C. In relation to the promotion of student achievement on the identification test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 109 and 110). Further analysis among the various group means was not justified.

D. In relation to the promotion of student achievement on the terminology test, the test results indicated the following (see Table 113):

1. The oral presentation alone was as effective as each of the visual presentations.

2. The detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w) and the heart model presentations (b & w and color).

E. In relation to the promotion of student achievement on the comprehension test, the F-ratio did not exceed the critical value for a 0.05 level test (see Tables 114 and 115). Further analysis among the various group means was not justified.

Interpretation: Ninth Grade Analyses
Immediate Retention

In terms of instructional effectiveness, economy, and simplicity of production:

1. The abstract line presentation (b & w) should be used to promote total student understanding of the concepts presented in the instruction.

2. The abstract line presentation (b & w) should be used to promote student learning of specific locations of the various patterns, structures, and positions of the parts in the heart.

3. The oral presentation alone should be used to promote student transfer of learning, i.e., the ability to identify the numbered parts on a diagram of the heart from information presented via the oral-visual presentation.

4. The detailed, shaded drawing presentation (b & w) should be used to promote student learning of the referents of terms.

5. The oral presentation alone should be used to promote the development of a new view, or reorganization, of the material by the student.

Interpretation: Tenth Grade Analyses
Immediate Retention

In terms of instructional effectiveness, economy, and simplicity of production:

1. The abstract line presentation (b & w) should be used to promote total student understanding of the concepts presented in the instruction.

2. The abstract line presentation (b & w) should be used to promote student learning of specific locations of the various patterns, structures, and positions of the parts in the heart.

3. The abstract line presentation (b & w) should be used to promote student transfer of learning, i.e., the ability to identify numbered parts on a diagram of the heart from information presented via the oral-visual presentation.

4. The abstract line presentation (color) should be used to promote student learning of the referents of terms.

5. The heart model presentation (b & w) should be used to promote the development of a new view, or reorganization, of the material by the student.

Interpretation: Eleventh Grade Analyses
Immediate Retention

In terms of instructional effectiveness, economy, and simplicty of production:

1. The abstract line presentation (b & w) should be used to promote total student understanding of the concepts presented in the instruction.

2. The abstract line presentation (b & w) should be used to promote student learning of specific locations of the various patterns, structures, and positions of the parts in the heart.

3. The abstract line presentation (b & w) should be used to promote student transfer of learning, i.e., the ability to identify the numbered parts on a diagram of the heart from information presented via the oral-visual presentation.

4. The oral presentation alone should be used to promote student learning of the referents of terms.

5. The oral presentation alone should be used to promote the development of a new view, or reorganization, of the material by the student.

Interpretation: Twelfth Grade Analyses
Immediate Retention

In terms of instructional effectiveness, economy, and simplicity of production:

1. The detailed, shaded drawing presentation (color) should be used to promote total student understanding of the concepts presented in the instruction.

2. The oral presentation alone should be used to promote student learning of the specific locations of the various patterns, structures, and positions of the parts in the heart.

3. The detailed, shaded drawing presentation (color) should be used to promote student transfer of learning, i.e., the ability to identify numbered parts on a diagram of the heart from information presented via the oral-visual presentation.

4. The detailed, shaded drawing presentation (color) should be used to promote student learning of the referents of terms.

5. The detailed, shaded drawing presentation (color) should be used to promote the development of a new view, or reorganization, of the material by the student.

Interpretation: Ninth Grade Analyses
Delayed Retention

In terms of instructional effectiveness, economy, and simplicity of production:

1. The oral presentation alone should be used to promote total student understanding of the concepts presented in the instruction.

2. The abstract line presentation (b & w) should be used to promote student learning of specific locations of the various patterns, structures, and positions of the parts in the heart.

3. The oral presentation alone should be used to promote student transfer of learning, i.e., the ability to identify the numbered parts on a diagram of the heart from information presented via the oral-visual presentation.

4. The oral presentation alone should be used to promote student learning of the referents of terms.

5. The oral presentation alone should be used to promote the development of a new view, or reorganization, of the material by the student.

Interpretation: Tenth Grade Analyses Delayed Retention

In terms of instructional effectiveness, economy, and simplicity of production:

1. The oral presentation alone should be used to promote total student understanding of the concepts presented in the instruction.

2. The oral presentation alone should be used to promote student learning of specific locations of the various patterns, structures, and positions of the parts in the heart.

3. The oral presentation alone should be used to promote student transfer of learning, i.e., the ability to identify the numbered parts on a diagram of the heart from information presented via the oral-visual presentation.

4. The oral presentation alone should be used to promote student learning of the referents of terms.

5. The oral presentation alone should be used to promote the development of a new view, or reorganization, of the material by the student.

Interpretation: Eleventh Grade Analyses Delayed Retention

1. The oral presentation alone should be used to promote total student understanding of the concepts presented in the instruction.

2. The oral presentation alone should be used to promote student learning of specific locations of the various patterns, structures, and positions of the parts in the heart.

3. The oral presentation alone should be used to promote student transfer of learning, i.e., the ability to identify numbered parts on a diagram of the heart from information presented via the oral-visual presentation.

4. The oral presentation alone should be used to promote student learning of the referents of terms.

5. The oral presentation alone should be used to promote the development of a new view, or reorganization, of the material by the student.

Interpretation: Twelfth Grade Analyses
Delayed Retention

1. The oral presentation alone should be used to promote total student understanding of the concepts presented in the instruction.

2. The oral presentation alone should be used to promote student learning of specific locations of the various patterns, structures, and positions of the parts in the heart.

3. The oral presentation alone should be used to promote student transfer of learning, i.e., the ability to identify numbered parts on a diagram of the heart from information presented via the oral-visual presentation.

4. The oral presentation alone should be used to promote student learning of the referents of terms.

5. The oral presentation alone should be used to promote the development of a new view, or reorganization, of the material by the student.

Table 116. Summary: Immediate Retention.

	Ninth Grade	Tenth Grade	Eleventh Grade	Twelfth Grade
Total Criterion Test	Abstract Line Pres. (b & w)	Abstract Line Pres. (b & w)	Abstract Line Pres. (b & w)	Detailed, Shaded Drawing Pres. (color)
Drawing Test	Abstract Line Pres. (b & w)	Abstract Line Pres. (b & w)	Abstract Line Pres. (b & w)	Oral Presentation
Identification Test	Oral Presentation	Abstract Line Pres. (b & w)	Abstract Line Pres. (b & w)	Detailed, Shaded Drawing Pres. (color)
Terminology Test	Detailed, Shaded Drawing Pres. (b & w)	Abstract Line Pres. (color)	Oral Presentation	Detailed, Shaded Drawing Pres. (color)
Comprehension Test	Oral Presentation	Detailed, Shaded Drawing Pres. (color)	Oral Presentation	Detailed, Shaded Drawing Pres. (color)

Table 116 indicates which instructional presentation, in terms of effectiveness, economy and simplicity of production, is most effective in facilitating student learning of specific educational objectives.

Table 117. Summary: Delayed Retention.

	Ninth Grade	Tenth Grade	Eleventh Grade	Twelfth Grade
Total Criterion Test	Oral Presentation	Oral Presentation	Oral Presentation	Oral Presentation
Drawing Test	Abstract Line Pres. (b & w)	Oral Presentation	Oral Presentation	Oral Presentation
Identification Test	Oral Presentation	Oral Presentation	Oral Presentation	Oral Presentation
Terminology Test	Oral Presentation	Oral Presentation	Oral Presentation	Oral Presentation
Comprehension Test	Oral Presentation	Oral Presentation	Oral Presentation	Oral Presentation

Table 117 indicates which instructional presentation, in terms of effectiveness, economy and simplicity of production, is most effective in promoting student retention of information relating to specific educational objectives.

Conclusions

The first null hypothesis was rejected for the ninth, tenth, eleventh and twelfth grades.

(H_1) There are no differences on the total criterion test in immediate retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

$$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$$

The second null hypothesis was rejected for the ninth, tenth, eleventh and twelfth grades.

(H_2) There are no differences on the four individual criterion tests in immediate retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

$$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$$

The third hypothesis could not be rejected for the ninth grade. However, there were several exceptions in the tenth, eleventh and twelfth grades. In the tenth grade on the total criterion test, the detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w). Similar results were also found for the drawing test. The abstract line presentation (b & w) was found to be more effective than the abstract line presentation (color) on the drawing test. On the comprehension test, the detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w).

For the eleventh grade, on the identification test the detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w). The realistic photographic presentation (b & w) was found to be more effective than the realistic photographic presentation (color) on the comprehension test.

For the twelfth grade on the total criterion test and the terminology test, the detailed, shaded drawing presentation (color) was more effective than the detailed, shaded drawing presentation (b & w).

(H_3) There are no differences on the four individual criterion tests in immediate retention among students receiving black and white illustrations and those receiving colored illustrations in complementing their oral instruction.

$$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$$

The fourth null hypothesis could not be rejected in the ninth, tenth, eleventh and twelfth grades.

(H_4) There are no differences on the total criterion test in delayed retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

$$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$$

The fifth null hypothesis was rejected for the ninth, tenth, eleventh and twelfth grades because of only one specific exception in the ninth grade in which the abstract line presentation (b & w) was more effective than the oral presentation on the drawing test.

(H_5) There are no differences on the four individual criterion tests in delayed retention among students receiving oral instruction complemented by visual illustrations possessing different amounts of realistic detail.

$$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$$

The sixth null hypothesis could not be rejected for the ninth, tenth, eleventh and twelfth grades.

(H_6) There are no differences on the four individual criterion tests in delayed retention among students receiving black and white illustrations in complementing their oral instruction.

$$H_o: \mu_I = \mu_{II} = \mu_{III} = \mu_{IV} = \mu_V = \mu_{VI} = \mu_{VII} = \mu_{VIII} = \mu_{IX}$$

The seventh null hypothesis was rejected for the immediate retention testing for the ninth, tenth, eleventh and twelfth grades. The seventh null hypothesis was rejected on the delayed retention testing for the ninth, tenth, eleventh and twelfth grades because of only one specific exception on the ninth grade drawing test in which the abstract line presentation (b & w) was more effective than the oral presentation alone.

(H_7) There are no significant differences in the relative effectiveness of the various types of visual illustrations used to complement oral instruction among the grade levels participating in the study--ninth, tenth, eleventh and twelfth.

Interpretation: Immediate Retention

The data collected in this study appear to support the contention that the logical realism for visual illustrations is not the most effective predictor of visual effectiveness. The findings of this study seem to substantiate the hypothesis that reality may be edited for instructional purposes. This particular view has been suggested by Travers, et al. (32, p. 1.18); they feel that the real objective of visual education is "not so much to bring the pupil into close touch with reality but to help students become more effective in dealing with reality." The process of editing reality for instructional purposes has been supported in recent research and literature: Jacobson (18); Attneave (2); Miller et al. (25); Broadbent (3, 4); Fleming (13); Travers, et al. (32); Travers (33) and Dwyer (10).

The literature seems to indicate that reality presents excessive stimuli which are hypothesized as interfering with the intended transmission of information. The main reasons explaining the inconsistencies in prediction of the visual realism continuum seem to be: (1) the additional stimuli contained in the realistic drawings and photographs seemed to interfere with the information to be transmitted, thereby reducing the effectiveness of the realistic drawings and photographs as efficient learning media; (2) students have been exposed to oral instruction in so many learning situations that, out of necessity, they have developed an ability to learn from oral instruction; (3) students have not been taught how to learn from photographs and realistic drawings; their exposure being merely to acquaint them with reality; and (4) students participating in this study viewed their respective types of visual illustrations for equal amounts of time--this situation would put the realistic drawings and photographs at a disadvantage if we can assume that the accuracy and the amount of information that can be perceived in a visual illustration depends to a certain degree on the amount of time available for viewing them.

A number of possible explanations may be advanced for the poor showing of the photographic presentation on the criterion tests. One is that the impact of excessive realistic detail may be sufficiently strong to detract attention from other equally relevant and important learning cues. For example, the learner may be so impressed by the amount of detail in the photographs that he may fail to identify and locate crucial learning cues. There is some evidence (Fleming, 13) that under certain conditions realistic detail increases the effectiveness of the visual presentation and perhaps reinforces the effect of the picture. By the same line of reasoning, it is conceivable that realistic detail may distract attention from other important learning cues, materials in the commentary or other visual cues in the illustration. In the final analysis, it is probably a question of determining what the crucial cues are in terms of realistic detail necessary to achieve the desired kinds of learning objectives.

The use of realistic detail in instructional illustrations which may superficially seem to call for realistic detail does not appear to be justified in terms of greater learning on the part of those who viewed the visual presentations. If detail is to be used effectively in instructional illustrations, there must be careful pre-production considerations of the probable psychological impact of specific uses of detail upon the learner and upon the specific learning objectives to be transmitted.

The superiority of the abstract linear representation seems to be in accordance with Attneave's research (2) which contends that only essentials travel through the nervous system to the brain and that lines bordering objects provides the essence of the information to be conveyed. For this same reason, Travers, et al., (32), feel that visual illustrations closely representing line drawings and containing the essence of the message to be transmitted would be more effective than more realistic illustration which would have to be coded by the central nervous system before transmission.

Interpretation: Delayed Retention

The differential effects of the nine treatments among the four grade levels disappeared on the delayed retention test with one exception (see Table 117). Miller, et al. (25) have warned against the assumption that one cue added to another would increase learning by a linear increment. The data obtained from the delayed testing analyses appear to substantiate the hypothesis proposed by Broadbent (3), Jackson (18), and Attneave (2) that one function of the perceptual system is to reduce excessive stimulation and to encode incoming information so that only the essentials travel through the nervous system to the brain. Travers and his colleagues (32) have stated that visual information is stored in the nervous system in some form isomorphic with line drawings, and that this permits the individual to more easily organize, remember, and reproduce edited information as opposed to more realistic information. Bruner, et al., (5) and Travers et al., (33), have stated that learners do not need highly embellished stimuli in order to recognize the attributes of an object or situation.

It may be that only the essentials which are initially perceived and encoded in edited form are retained over extended periods of time. Attneave's research (2) supports this particular concept. He found that lines bordering objects provide the essence of the information to be conveyed.

Recommendations for Further Research

To date, there has been very little research in the audio-visual field relating to the specific effects of the various types of visual illustrations when used for either general or specific educational objectives. If quality is to be continually sought in the teaching-learning situation, it is important for specific research to be continued in seeking ways of improving instructional techniques. This investigation covers a limited content area; however, it opens avenues for further research.

1. Since this is one of the initial studies investigating the relative effectiveness of various types of visual illustrations in complementing oral instruction, it is desirable to replicate it in the same and in other content areas in order to establish confidence in the results.

2. On the basis of the present study, it is indicated that research into the use of visual illustrations in complementing oral instruction is warranted. Visuals have been found to be effective in the sense they achieve more expeditiously those objectives that would have been achieved only to a lesser degree had the visuals not been used to complement the oral instruction. Effective and efficient visual illustrations cannot be designed and prepared to achieve specific objectives without taking into account the various educational and psychological characteristics of the student. It seems only reasonable to expect that further research relating to visual media will be characterized by its orientation to specific kinds of students, i.e., their grade level, background characteristics, I.Q. levels, sex, etc. The subject content and the types of objectives to be facilitated by the visuals would more than likely be an important consideration in the development of instructional visuals. Considering the important and immediate need educators have for information relating to the factors as cited above in this paragraph, the following suggestion is proposed as being the most efficient means of obtaining information of this nature. An agency

interested in education and/or responsible for producing instructional (visual) materials should fund or conduct a systematic and simultaneous research program designed to provide answers to the problems which, at the present time, are limiting the instructional effectiveness and efficiency of teachers at all levels.

3. The relative effectiveness of varied types of visual illustrations remains a very important question both practically and theoretically. This study was an initial attempt in determining the predictability of learning effectiveness inherent within various types of visual illustrations for specific types of learning objectives. This line of research has significant implications on curriculum planning and methods of school instruction. Educators at the present time have to select their instructional materials from whatever is available from those agencies developing instructional materials. When the research on visual illustrations has been carried to its logical conclusions, significant changes will be effected in the types of visual materials used and in the course organizations themselves. Educators will be able to approach material producers and specify the types of visuals they need to accomplish a specific job most effectively. In order for this to occur curriculum coordinators should work very closely with department heads and teachers in defining in specific terms those behavioral objectives that they wish to transmit and how they are to proceed in achieving these objectives. Once the objectives have been defined, the educators will be able to select those types of visual illustrations which have been found to be most effective in promoting learning of that particular type of objective. This kind of visual selection will become an indigenous part of any course development program. Only when the predictability of varied types of visual illustrations in terms of learning effectiveness has been thoroughly researched and publicized will educators be able to prepare specifications for the visual media that they wish to use to achieve specific instructional objectives. Only when this level has been attained will educators be able to approach representatives of agencies responsible for producing instructional media and request materials to be designed to achieve specific educational objectives.

4. Even though this study indicates that realistic drawings and photographs contain more information than the learner can effectively use because of his limited channel capacity, this superfluous detail may have important functional value over long periods of time. In the present study the delayed testing was conducted two weeks after the immediate testing session. Further research needs to be conducted at predetermined intervals of time over a period of two or more years to determine whether, in fact, visuals complementing oral instruction are no more effective than the oral presentation alone in facilitating varied types of student learning.

5. The results of this study seem to indicate that considerable research needs to be conducted in relation to the types of visual materials presented via motion picture and televised instruction. This study indicates that when groups of students are assembled to view instructional presentations for equal amounts of time the types of visuals which have edited detail are the ones that appear to be most effective in promoting specific types of learning.

6. Today's teachers are using a greater variety of visual media in their instructional presentations. This does not mean, however, that the use of visual materials is thereby improving instructional effectiveness. Teachers, in general, use visual material rather indiscrimately. They are often unaware of what instructional effects the visual media have on the students and whether the visual materials do, in fact, improve student learning of general and specific educational objectives. However, there is also another serious problem which needs to be considered. At a time when so much of today's information is presented to students visually, it is imperative that students be given some type of "visual training" so that they will be better prepared to accurately perceive and organize information inherent in various types of visual illustrations. Students should be taught how to examine visual materials critically. Most students have been exposed to visual materials (realistic drawings and photographs) merely as a means of acquainting them with reality. Very few students have ever participated in a systematic approach designed to reveal specific information inherent within varied types of visual illustrations. What appears to be needed in this area is the development of a pilot program which would expose students to a comprehensive approach designed to acquaint them with the techniques and methods of critically examining visual illustrations and the types of information contained within them.

7. Further investigation is needed with the present study to determine the effectiveness of the various types of visual illustrations in achieving other varied educational objectives.

8. It should be ascertained whether the results would change significantly if the students were allowed to progress through their respective presentations at their own rate, i.e., via programed instruction booklets.

9. It should be ascertained whether the various learning continuum would change if each student received his respective instruction individually.

10. Studies similar to this one should be designed and conducted both at the elementary school level and at the college level.

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APPENDIX A

Physiology Test

In the following multiple choice questions, select the answer which you feel best answers the question and place it on your answer sheet.

1. The part of the tooth which contains the hardest substance in the body is the

   (a) root
   (b) dentine
   (c) cement
   (d) enamel

2. The digestion of food occurs principally in the

   (a) stomach
   (b) small intestine
   (c) mouth
   (d) large intestine

3. Contraction of the smooth muscle of the alimentary canal is called:

   (a) peristalsis
   (b) digestion
   (c) absorption
   (d) assimilation

4. A blood vessel which carries deoxygenated blood is the

   (a) aorta
   (b) pulmonary artery
   (c) hepatic artery
   (d) pulmonary vein

5. Worn-out red blood cells are decomposed in the

   (a) heart
   (b) lungs
   (c) kidneys
   (d) liver

6. "Swollen glands" means an enlargement of the

   (a) lymph nodes
   (b) heart valves
   (c) vena cava
   (d) portal vein

7. The chief value of perspiration is that it

(a) eliminates body odors
(b) opens the pores
(c) reduces weight
(d) regulates body temperature

8. Endocrine glands produce

(a) chyme
(b) endoplasm
(c) hormones
(d) serums

9. The body is stimulated to unusual activity by increased secretion from the

(a) pancreas
(b) adrenal glands
(c) thyroid gland
(d) thymus gland

10. The spinal cord is made up of

(a) bone tissue
(b) cartilage tissue
(c) connective tissue
(d) nerve tissue

11. Nerves from the eyes and ears are connected to the

(a) cerebellum
(b) cerebrum
(c) medulla
(d) spinal cord

12. The chromosome number of the body cells of identical human twins is

(a) 12
(b) 24
(c) 48
(d) 96

13. The person who can give blood to any other person but can receive only his own type blood, has blood type

(a) A
(b) 0
(c) AB
(d) B

14. The backward flow of blood in the veins is prevented by

(a) muscles
(b) valves
(c) the heart beat
(d) lymphatics

15. The chamber of the heart which pumps oxygenated blood to all the parts of the body is the

(a) left auricle
(b) right ventricle
(c) right auricle
(d) left ventricle

16. The ribs are attached to the spine and meet in front of the body at the

(a) skull
(b) limbs
(c) joints
(d) breastbone

17. The ribs protect the

(a) stomach
(b) breastbone
(c) spinal cord
(d) lungs

18. The hollow interior of the long bones is filled with

(a) marrow
(b) minerals
(c) red and white corpuscles
(d) Haversian canals

19. The windpipe is located _______________ the esophagus

(a) in front of
(b) behind
(c) to the left of
(d) to the right of

20. The carbon dioxide-oxygen exchange with the atmosphere occurs in the

(a) nose
(b) trachea
(c) lungs
(d) bronchi

21. Blood is oxygenated in the capillaries of the

(a) air sacs
(b) heart
(c) muscle
(d) liver

22. During inspiration, the ribs

(a) do not move
(b) move downward
(c) move inward
(d) move upward

23. The part of the brain that controls respiration is the

(a) medulla
(b) cerebellum
(c) cerebrum
(d) spinal cord

24. A defense of the body against bacteria is

(a) hemoglobin
(b) phagocytes
(c) red blood cells
(d) blood platelets

25. The disease hemophilia is associated with

(a) the bone structure
(b) blood clotting
(c) the structure of nervous tissue
(d) the formation of red corpuscles

26. The liquid that bathes every cell and acts as a medium of exchange is

(a) cell sap
(b) fibrinogen
(c) lymph
(d) fibrin

27. Urine is stored in an organ called the

(a) diaphragm
(b) kidney
(c) bladder
(d) lungs

28. Secretions of the ductless glands pass

(a) into tubes or ducts
(b) directly into the blood
(c) directly into the organs where they are used
(d) out of the body

29. Inactivity of the thyroid gland from infancy may produce a condition known as

(a) diabetes
(b) beriberi
(c) cretinism
(d) Addison's disease

30. The concentration of sodium and potassium in the blood is controlled by

(a) adrenin
(b) cortin
(c) insulin
(d) secretin

31. Diabetes is caused by the improper functioning of the

(a) parathyroids
(b) thyroids
(c) pancreas
(d) adrenals

32. Blood enters the heart through

(a) arteries
(b) vena cavas
(c) aortic arch
(d) pulmonary veins

33. Blood leaves the heart through the

(a) tricuspid valve
(b) aorta
(c) superior vena cava
(d) mitral valve

34. The portion of the heart which divides it longitudinally into two halves is called the

(a) exicaidium
(b) pericardium
(c) septum
(d) myocardium

35. The adult human heart is said to beat approximately ___ times per minute

(a) 85
(b) 72
(c) 60
(d) 58

36. Growth and repair of body tissues involves

(a) protein
(b) fats
(c) starch
(d) sugar

APPENDIX B

CRITERION TESTS

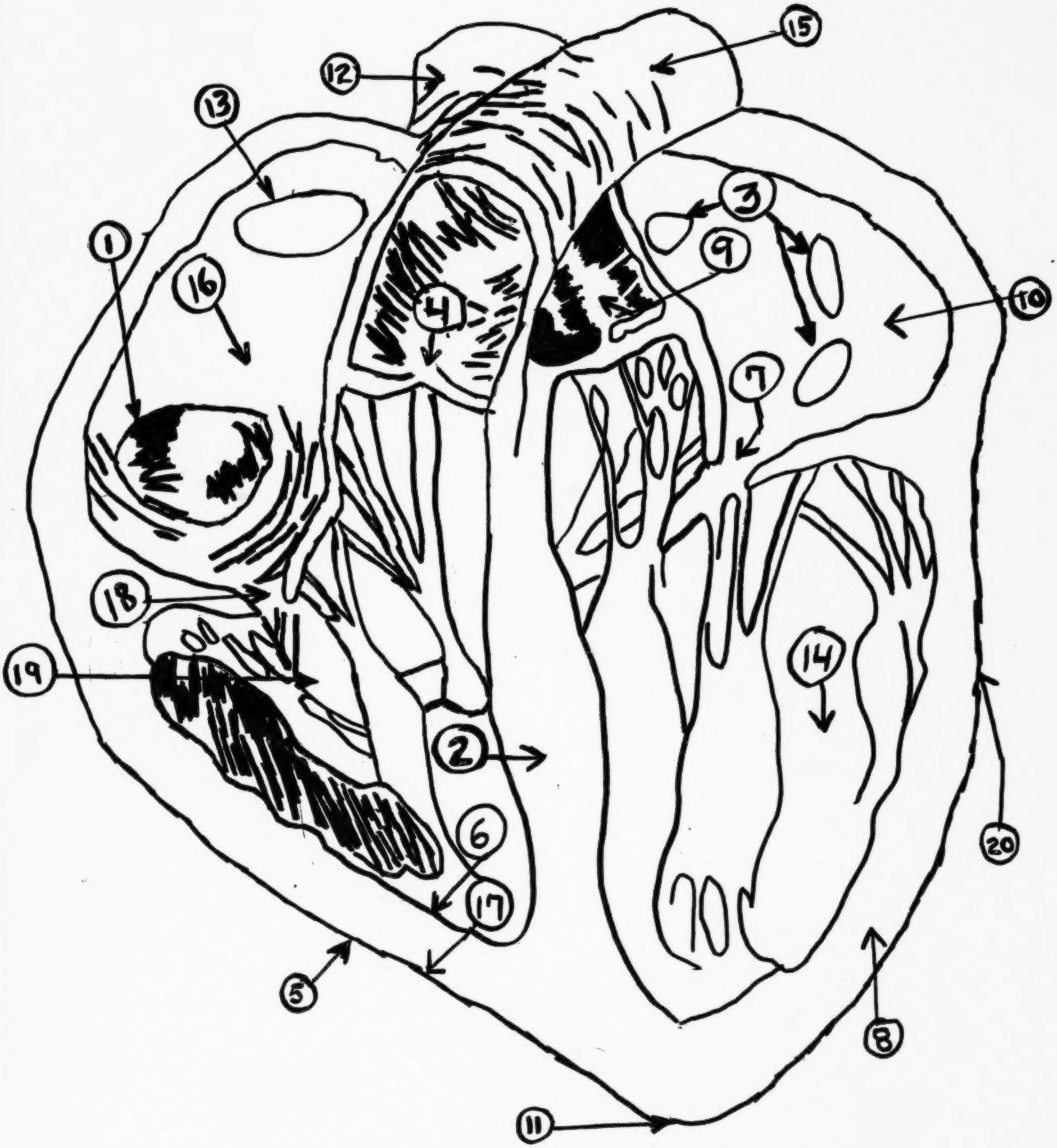
Name ______________________________ Grade ____________

Drawing Test

Draw a picture of a heart and place the number of the identified parts where they would be located on the heart.

1. superior vena cava
2. aorta
3. tricuspid valve
4. pulmonary vein
5. septum
6. epicardium
7. aortic valve
8. pulmonary valve
9. inferior vena cava
10. pulmonary artery
11. myocardium
12. endocardium
13. mitral valve
14. right auricle
15. right ventricle
16. left auricle
17. left ventricle
18. apex

Identification Test


15
12
13
3
1
9
16
10
4
7
18
19
14
2
20
6
17
5
8
11

Select the answer you feel best identifies the part of the heart indicated by the numbered arrows and mark the corresponding letter on the provided answer sheet.

1. Arrow number one (1) points to the
   a. aorta
   b. mitral valve
   c. superior vena cava opening
   d. inferior vena cava opening
   e. septum

2. Arrow number two (2) points to the
   a. pericardium
   b. endocardium
   c. septum
   d. myocardium
   e. pulmonary artery

3. Arrow number three (3) point to the
   a. inferior vena cava openings
   b. superior vena cava openings
   c. aortas
   d. pulmonary veins
   e. pulmonary arteries

4. Arrow number four (4) points to the
   a. pulmonary vein
   b. pulmonary artery
   c. aorta
   d. tricuspid valve
   e. mitral valve

5. Arrow number five (5) points to the
   a. myocardium
   b. ectoderm
   c. pericardium
   d. endocardium
   e. aortic base

6. Arrow number six (6) points to the
   a. endocardium
   b. myocardium
   c. pericardium
   d. muscle
   e. septum

7. Arrow number seven (7) points to the
   a. venic valve
   b. pulmonary valve
   c. tricuspid valve
   d. mitral valve
   e. aortic valve

8. Arrow number eight (8) points to the
   a. pericardium
   b. endocardium
   c. ectocardium
   d. ectoderm
   e. myocardium

9. Arrow number nine (9) points to the

a. superior vena cava opening
b. inferior vena cava opening
c. aortic valve
d. pulmonary valve
e. mitral valve

10. Arrow number ten (10) points to the

a. right auricle
b. right ventricle
c. left auricle
d. left ventricle
e. pulmonary artery

11. Arrow number eleven (11) points to the

a. pericardium
b. myocardium
c. endocardium
d. endoderm
e. apex

12. Arrow number twelve (12) points to the

a. septum
b. aorta
c. pulmonary artery
d. pulmonary veins
e. none of these

13. Arrow number thirteen (13) points to the

a. superior vena cava opening
b. right auricle
c. mitral valve
d. tricuspid valve
e. none of these

14. Arrow number fourteen (14) points to the

a. right ventricle
b. left ventricle
c. left auricle
d. right auricle
e. pericardium

15. Arrow number fifteen (15) points to the

a. pulmonary vein
b. aorta
c. pulmonary artery
d. right auricle
e. aortic valve

16. Arrow number sixteen (16) points to the

a. right ventricle
b. right auricle
c. left ventricle
d. left auricle
e. epicardium

17. Arrow number seventeen (17) points to the

a. epicardium
b. pericardium
c. endocardium
d. myocardium
e. none of these

18. Arrow number eighteen (18) points to the

a. aortic valve
b. pulmonary valve
c. mitral valve
d. tricuspid valve
e. septic valve

19. Arrow number nineteen (19) points to the

a. left ventricle
b. right ventricle
c. right auricle
d. left auricle
e. vascular space

20. Arrow number twenty (20) points to the

a. myocardium
b. endocardium
c. ectocardium
d. epicardium
e. none of these

Name ______________________________ Grade ____________________

Terminology Test

This section required that you complete each sentence with a specific word or words. In several places you may use more than one word to complete your answer.

Write you answer to the left of each question.

______________ 1. _____ are the thick walled chambers of the heart.

______________ 2. The heartbeat consists of two parts; the contraction of the ventricle is called the _____.

______________ 3. The relaxation of the ventricles is called the _____.

______________ 4. Blood from the right ventricle leaves the heart through the _____.

______________ 5. _____ is the strongest section of the heart.

______________ 6. When blood comes back to the heart from the lungs, it enters the _____.

______________ 7. Vessels that allow the blood to flow from the heart are called _____.

______________ 8. Blood passes from the left ventricle out the aortic valve to the _____.

______________ 9. The chamber of the heart which pumps oxygenated blood to all parts of the body is the _____.

______________ 10. _____ is another name for the part of the heart called the heart muscle.

______________ 11. _____ is the part of the heart which controls its contraction and relaxation.

______________ 12. _____ is the name given to the inside lining of the heart wall.

________________ 13. Blood enters the heart from the (left or right) side.

________________ 14. _____ are the vessels that have no valves at their openings.

________________ 15. _____ allow blood to travel in one direction only.

________________ 16. _____ is the passage between right auricle and the right ventricle.

________________ 17. _____ is located between the left auricle and the left ventricle.

________________ 18. (18) and (19) are the names of two valves which have three triangular flaps and are

________________ 19. sometimes called the semilunar valves.

________________ 20. Immediately before entering the aorta, blood must pass through the _____.

Comprehension Test

In the following multiple choice questions, select the answer which you feel best answers the question and place it on your answer sheet.

1. Which valve is most like the tricuspid in function?

   a. pulmonary
   b. aortic
   c. mitral
   d. superior vena cava

2. When blood is being forced out the right ventricle in what position is the tricuspid valve?

   a. partially opened
   b. partially closed
   c. open
   d. closed

3. When blood is being forced out the aorta is it also being forced out of the

   a. pulmonary veins
   b. pulmonary artery
   c. superior vena cava
   d. cardiac artery

4. The contraction impulse in the heart starts in the

   a. septum
   b. both ventricles simultaneously
   c. both auricles simultaneously
   d. arteries

5. In the diastolic phase the ventricles are:

   a. fully contracted
   b. partially contracted
   c. fully relaxed
   d. partially relaxed

6. During the systolic phase in what position will the mitral valve be?

   a. partially open
   b. open
   c. partially closed
   d. closed

7. During the systolic phase blood is being forced through the

   a. pulmonary and aortic arteries
   b. superior and inferior vena cavas
   c. tricuspid and mitral valve
   d. pulmonary veins

8. When blood is entering through the vena cavas it is also entering through the

   a. mitral valve
   b. pulmonary veins
   c. pulmonary artery
   d. aortic arch

9. When the heart contracts, the

   a. auricles and ventricles contract simultaneously
   b. ventricles contract first, then the auricles
   c. right side contracts first, then the left side
   d. auricles contract first then the ventricles

10. While impure blood is entering the superior vena cava, it is also entering through the

    a. pulmonary veins
    b. aortic arch
    c. inferior vena cava
    d. pulmonary artery

11. When blood leaves the heart through the aorta, it is also simultaneously leaving the heart through the

    a. aortic arch
    b. pulmonary veins
    c. pulmonary artery
    d. pulmonary valve

12. When the pressure in the right ventricle is superior to that in the pulmonary artery what position is the tricuspid valve in?

    a. closed
    b. open
    c. partially closed
    d. confined by pressure from the right auricle

13. Which one of the following statements is false? When the auricles contract, blood is forced out the

    a. superior and inferior vena cavas
    b. pulmonary veins
    c. tricuspid and mitral valves
    d. aortic and pulmonary valves

14. Blood leaving the heart through the aorta had left the heart previously through the

    a. vena cavas
    b. pulmonary veins
    c. pulmonary artery
    d. tricuspid and mitral valves

15. When blood in the aorta is exerting a superior pressure on the aortic valve what is the position of the mitral valve?

    a. closed
    b. open
    c. partially open
    d. closed by pressure from the left ventricle

16. When the mitral and tricuspid valves are forced shut, in what position is the pulmonary valve?

    a. closed
    b. partially open
    c. open
    d. partially closed

17. During the systolic phase in what position is the aortic valve?

    a. fully open
    b. partially open
    c. partially closed
    d. fully closed

18. Blood is being forced out the pulmonary veins simultaneously as blood is:

    a. entering the vena cavas
    b. being forced out the aortic and pulmonary valves
    c. passing through the mitral and tricuspid valves
    d. being forced through the pulmonary artery

APPENDIX C

HEART SCRIPT

The human heart is a hollow, bluntly conical muscular organ. Its pumping action provides the force that circulates the blood through the body. In the average adult, the heart is about five inches long and about two and one half inches thick. A man's heart weighs about 11 ozs. and a woman's heart weighs about 9 ozs.

The heart lies toward the front and is in a slanting position between the lungs, immediately below the breastbone. The wide end points toward the right shoulder. The small end of the heart points downward to the front of the chest and toward the left. The lower portion of the heart is called the apex and is the part that you feel beating.

In order to better comprehend the following instruction, it will be helpful to visualize a cross-section view of a heart in your mind's eye. As you visualize it, the right side of the heart will be on the left side. In other words, as you look at the heart, its right side will appear on your left side.

To understand the functioning of the heart you will need to be able to identify the parts of the heart. The heart is enclosed in a thin double-walled sac. The layer which forms the outer wall of the sac is called the pericardium. It is composed of a tough, transparent elastic tissue. It protects the heart from rubbing against the lungs and the walls of the chest. The inner portion of the double walled sac is called the epicardium. It is attached to the heart muscle.

The myocardium is called the heart muscle; it controls the contraction and relaxation of the heart. The myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood throughout the body. The myocardium varies in thickness. For example auricle walls are thin when compared to the thickness of the ventricles.

The endocardium is the name given to the inside lining of the heart wall.

The human heart is really two hearts combined in a single organ which pumps blood to all parts of the body. The heart is divided longitudinally into two halves by the septum. In other words, the septum divides the heart into two halves. The two halves may be compared to a block of two houses, which are independent of each other but have a common wall, the septum, between them.

Each half of the heart is divided into an upper chamber and a lower chamber. The upper chambers being called auricles and the lower chambers being called ventricles. Although there is no direct communication between the right and left sides, both sides function simultaneously.

The upper chamber on each side of the septum are auricles and the lower chambers are called ventricles. Auricles have thin walls and act as receiving rooms for the blood while the ventricles below act as pumps pumping the blood away from the heart.

As you would view a cross-sectional diagram of the heart, blood enters the right auricle through veins. Only veins carry blood to the heart. The superior and inferior vena cavas are the two veins which deposit blood in the right auricle. There are no valves at the openings of these veins into the right auricle. The superior vena cava drains blood into the right auricle from all body parts above heart level, i.e., head, and the arms.

The other vein, the inferior vena cava deposits also in the right auricle blood from the trunk and legs--from regions below the heart level. As blood from the body fills the right auricle, some of it begins to drip into the right ventricle immediately.

The auricles and ventricles on each side of the heart communicate with each other through openings. The opening between the right auricle and right ventricle is called the tricuspid valve. This valve consists of three triangular flaps of thin, strong, fibrous tissue. These flaps permit the flow of blood into the right ventricle, but prevent it from flowing backward into the right auricle because the ends of the flaps are anchored to the floor of the right ventricle by slendor tendons.

The three flaps act like swinging doors which open only in one direction. Thus, blood passes from the right auricle through the tricuspid valve into the right ventricle. As soon as the right ventricle is filled with blood, both ventricles begin to contract.

The first effect of the pressure produced in the right ventricle is to force blood behind the flaps of the tricuspid valve.

While the blood pressure behind the flaps brings the flaps together and prevents the flow of blood, the contraction of the right ventricle continues until the blood presses hard enough to open the pulmonary valve and forces the blood into the pulmonary artery. The pulmonary valve is located between the right ventricle and the pulmonary artery.

The pulmonary valve (like the tricuspid valve) consists of three flaps which fill with blood backing up in the pulmonary artery. As soon as the right ventricle begins to relax from its contraction, the pulmonary valve prevents blood from flowing back into the right ventricle. The pulmonary valve only opens when the pressure in the right ventricle is greater than the pressure in the pulmonary artery forcing the blood on into the pulmonary artery.

Since the pulmonary valve is composed of flaps or pockets, which the swollen pulmonary artery quickly fills with blood as soon as the right ventricle begins to relax from its contraction. The flaps or pockets of the valve are thus pressed together, and no blood flows back into the right ventricle.

After the blood passes through the pulmonary valve it enters the pulmonary artery from which it is carried up through the heart to both the left and right lungs where it is cleansed and oxygenated.

Returning from the lungs the blood enters the heart through four pulmonary veins and collects in the left auricle.

Like the right auricle, the left auricle also contracts when it is full, squeezing blood through the mitral valve into the left ventricle. The mitral valve is located between the left auricle and the left ventricle.

The mitral valve is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the mitral valve thereby closing the way back to the left auricle.

The contraction of the left ventricle pumps the blood through the entire body. For this reason it is the largest, strongest, and most muscular section of the heart. When the left ventricle, which is filled with blood, contracts the resulting pressure in the ventricle opens the aortic valve located in the mouth of the great aorta.

The aorta is the large artery which carries the blood from the left ventricle.

The Circulation of the Blood

The directional flow of blood in the heart is determined by valves which allow the blood to flow in only one direction.

Both auricles receive blood simultaneously through unguarded openings in the veins. The right auricle receives its blood through the superior and inferior vena cavas while the left auricle receives its blood through the pulmonary veins.

A wave of muscular contraction starts at the top of the heart and passes downward, simultaneously, over both sides of the heart, for example, both auricles contract at the same time and then relax as the contraction passes down to the ventricles. When the auricles are caused to contract they become small and pale and in doing so the blood in their chambers is subjected to increased pressure which forces blood through both the tricuspid and mitral valves.

As the ventricles fill, eddies of the blood float the flaps on both the tricuspid and mitral valves out to a partially closed position.

As the ventricle pressure becomes greater than that in the auricles, the valves are tightly closed and so prevent blood from being forced backward into the auricles.

While the auricles are relaxing from the contraction, blood flows into them from the veins before the contraction of the ventricles is initiated.

The instant that the contraction of the auricles has been completed the ventricles are stimulated to contract; this contraction increases the pressure in the chambers forcing the valves, both the tricuspid and mitral, completely shut.

The semi-lunar valves, the three flapped valves, both the pulmonary and aortic that guard the entrances to the pulmonary artery on the right and the aortic artery on the left respectively, are closed by the back pressure provided by blood already in these vessels. When pressure provided by blood already in these vessels. When pressure in the ventricles becomes greater than that in the exit vessels, the pulmonary and aortic valves (open).

Blood flows from the right ventricles into the pulmonary artery on route to the lungs and from the left ventricle into the aorta for distribution through the entire body.

Immediately following ejection of blood into the arteries, the ventricles begin to relax; this lowers the pressure within their chambers and the greater pressure in the arteries closes the semilunar valves. Pressure within the ventricle is sufficient, however, to maintain closure of the tricuspid and matril valves against the already increasing auricle pressure.

As the ventricles relax further, pressure within them decreases correspondingly, and the tricuspid and mitral valves are forced open by increased auricle pressure, caused by blood flowing into them from the veins. So before the next auricle contraction, blood is already flowing from the auricles into the ventricles because of a greater blood pressure existing in the auricles over that which exists in the ventricles.

The Cycle of the Heartbeat Consists of Two Parts

The relaxation of the ventricles, during which they are filled with blood is called the diastolic phase.

The heart relaxes between beats in the diastolic phase. Blood flows into the heart filling both auricles. While blood is flowing into the auricles the recoil of the artery wall still maintains part of the pressure developed by the contraction of the ventricles. This is the time of lowest pressure in the arteries or what is called the diastolic pressure.

The contraction phase or systolic phase begins when the auricles contract. The blood forces its way through the mitral and tricuspid valves into the ventricles.

The ventricles contract and force the blood through the semilunar valves--pulmonary and aortic valves.

After passing through the pulmonary and aortic valves the blood passes into the pulmonary and aortic arteries.

The blood leaves the ventricles under terrific pressure and surges through the arteries with a force so great that it bulges their elastic walls. At this point, arterial blood pressure is greatest; we refer to this pressure as the systolic pressure.

The heart relaxes again and the tricuspid and mitral valves close. Blood flows into the auricles, the mitral and tricuspid valves are forced open and the cycle begins again.

APPENDIX D

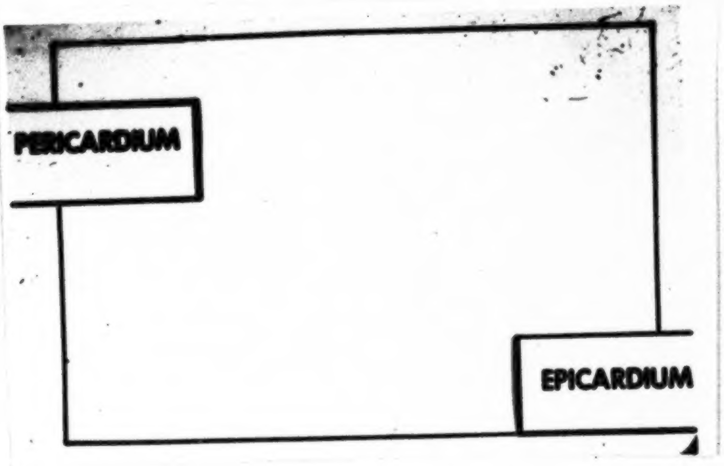
Kuder-Richardson Formula 21 Reliability Coefficients

	Ninth Grade		Tenth Grade		Eleventh Grade		Twelfth Grade	
	Retention		Retention		Retention		Retention	
	Immed.	Delayed	Immed.	Delayed	Immed.	Delayed	Immed.	Delayed
Pretest	.51	.87	.53	.90	.61	.90	.72	.91
Drawing Test	.82	.83	.86	.85	.88	.84	.82	.84
Identification Test	.74	.72	.77	.76	.77	.74	.77	.76
Terminology Test	.66	.69	.68	.66	.69	.74	.83	.82
Comprehension Test	.50	.60	.69	.59	.63	.60	.65	.63
Total Criterion Test	.87	.90	.90	.90	.90	.91	.91	.92

APPENDIX E

Sample Visual Illustrations

Oral Presentation (Group I)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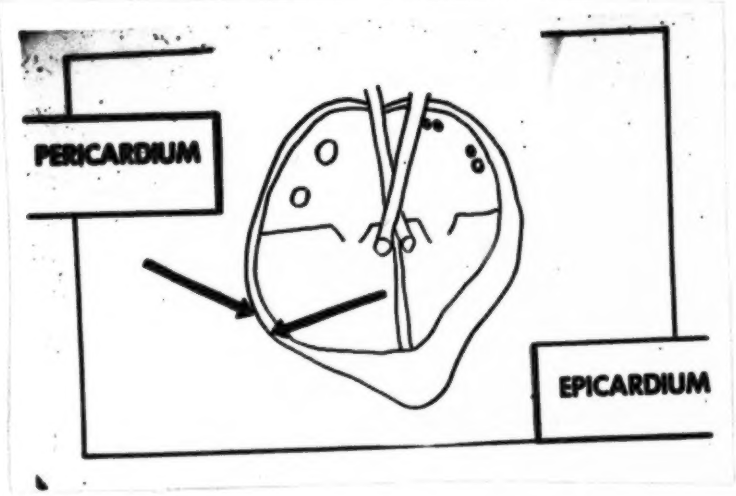
EPICARDIUM

Abstract Line (B & W)
Group II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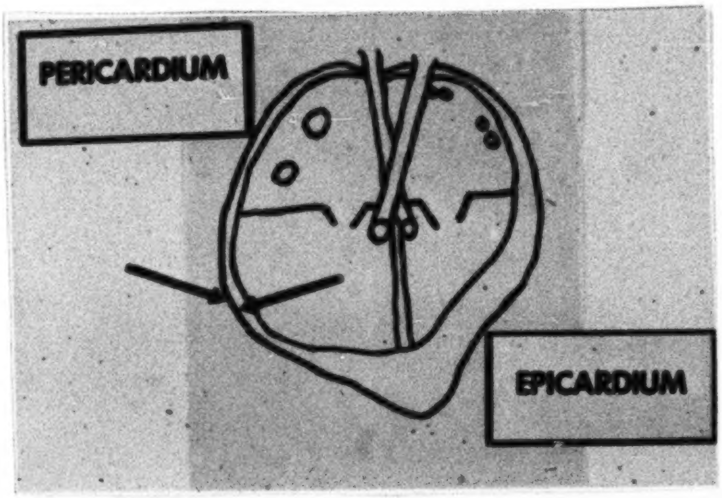
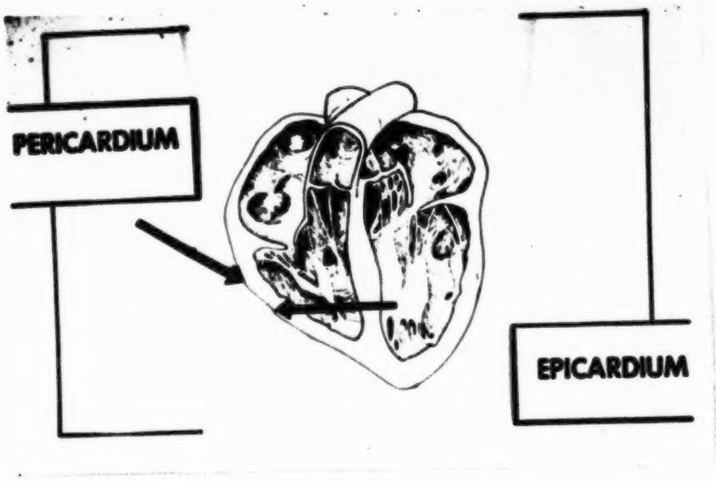
EPICARDIUM

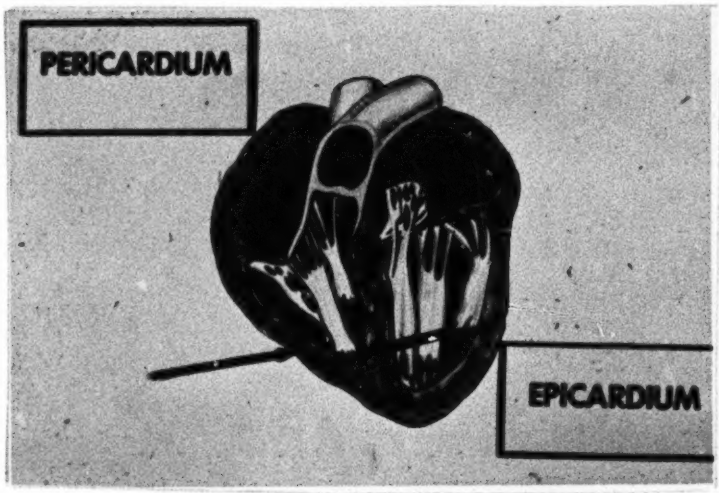
Abstract Line (Color)
Group III


PERICARDIUM
EPICARDIUM

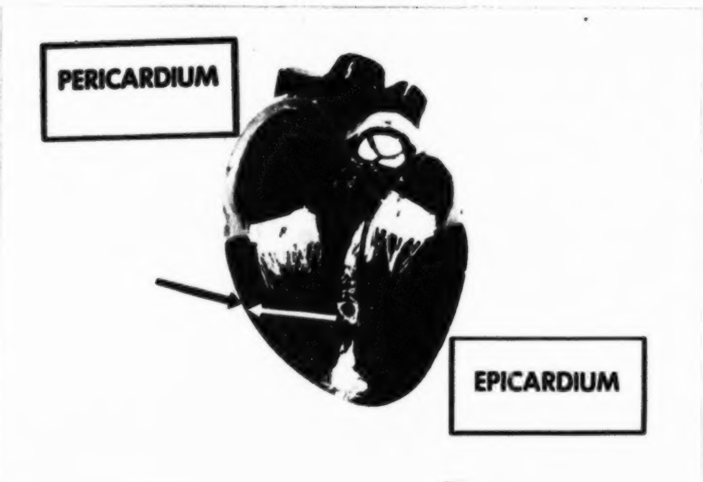
Detailed, Shaded (B & W)
Group IV


PERICARDIUM
EPICARDIUM

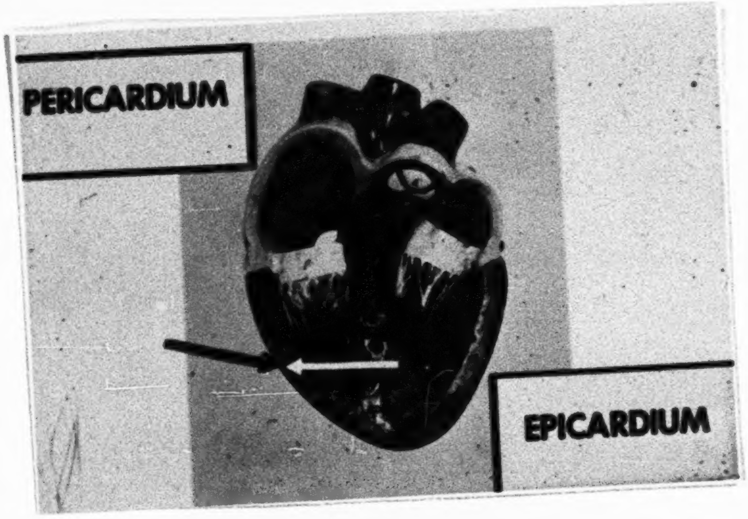
Detailed, Shaded (Color)
Group V


PERICARDIUM
EPICARDIUM

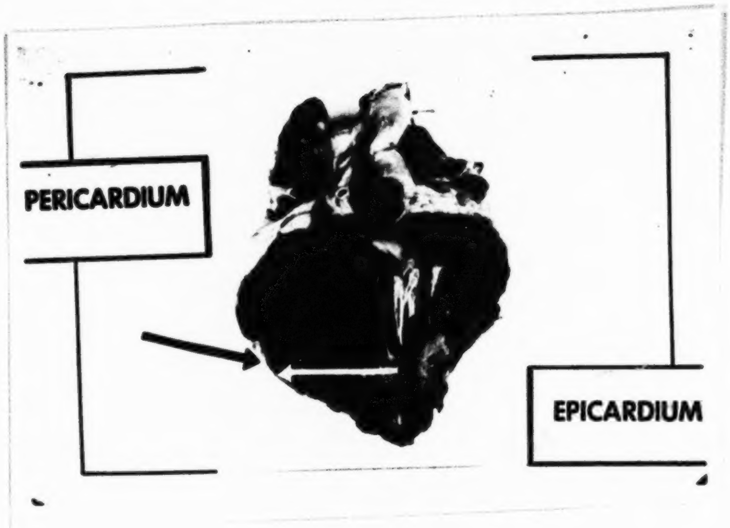
Heart Model (B & W)
Group VI


PERICARDIUM
EPICARDIUM

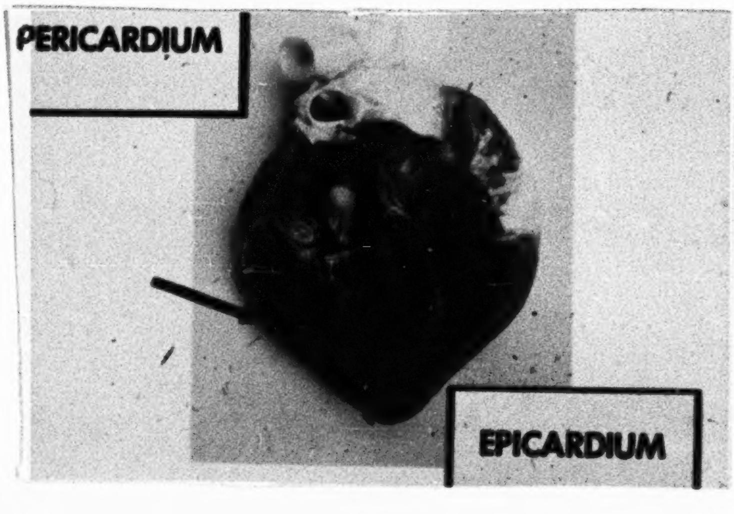
Heart Model (Color)
Group VII


PERICARDIUM
EPICARDIUM

Realistic Photographic
(B & W) Group VIII


PERICARDIUM
EPICARDIUM

Realistic Photographic
(Color) Group IX


PERICARDIUM
EPICARDIUM

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